Master thesis Port, Urban & Transport Economics

Erasmus University Rotterdam

The influence of parking tariffs and quality of the public transport on commuters mode choice

Determining the effects of parking tariffs and quality of the public transport on commuters mode choice between car and public transport with help of a mixed-effects logistic regression analysis

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Preface

This master thesis is the completion of my study 'Economics & Business Economics' at the Erasmus University Rotterdam. In September 2011 I started and after three years of study I accomplished my bachelor. Then I started the master 'Urban, Port & Transport Economics' which pleased me very well.

From November 2015 I went to work with my master thesis which lies ahead. To be honest it was tough to be disciplined all the time. Gladly, slowly but surely the research was taking shape. Now I am very proud that I can present my research to you.

In the first place I should like to thank my parents. They have always supported me in both starting and finishing my study. Furthermore I like to thank Jan-Jelle Witte for his guidance during the writing process. Its due to his hints, constructive criticism and knowledge that I could able to finish this thesis. I also thank Giuliano Mingardo for his willingness to act as second reader. At last I want to thank my girlfriend, friends and classmates for their support and the contribution of a nice time as a student.

I hope that you will enjoy reading this master thesis!

Chris Harrewijn

Sliedrecht, 30 September 2016

Summary

The presented study analysis travel mode choice for commuters between car and public transport modes. The aim of the study is to find out if parking tariffs and the quality of the public transport have an influence on commuters mode choice. The models are build with the help of a mixed-effects logistic regression with two levels. Level 1 contains control variables at personal level and level 2 contains control variables at municipality level and also included the variables of interest parking tariffs and quality of the public transport. Data was gathered from different sources like OViN, CBS and NPR. The used dataset has 21.323 observations in 418 municipalities in the Netherlands. The results shows that both parking tariffs as quality of the public transport has a positive significant influence on the use of public transport modes. But there is not a significant interaction effect found between those two variables. A focus on one of the two should be a good recommendation for policy makers to persuade people to switch from the car to public transport modes.

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Introduction

In the last decennia the total amount of vehicles on the road is expanding. From 2004 till 2015 this amount is increased with 15% in the Netherlands(CBS, 2015b). Also the amount of traveled kilometers on the road network is increasing over the years(Ministerie van Infrastructuur en Milieu, 2012). In 2014 people in the Netherlands are making on average 2,69 trips per day (CBS, 2015a)(Gemeente Rotterdam, 2015). A lot of these trips are commuting trips: from work to home and vice versa. In the Netherlands approximately 30% of all journeys are commuting trips, which is about the same percentage as most Western countries(Heinen et all, 2013). Because a lot of these commuting trips take place at the same time at bottlenecks, these trips have a large impact on traffic congestion. The government in the Netherlands is trying to reduce the traffic with some measures as attracting people to the bicycle, better information systems about transport modes, contact with schools and companies and more P&R locations(Ministerie van Infrastructuur en Milieu, 2015a). There was even an initiative called 'Wild! van de spits' to pay people when they use other options than the car in peak times(Ministerie van Infrastructuur en Milieu, 2015b). Nevertheless a lot of car users are unwilling to switch from the car to for example Public Transport(PT), therefore governments should try to reduce the functional, psychological and cultural values of the car and increase the performance of the public transport(Steg, 2003).

Now it is interesting to understand which factors really drive the choice for car or PT to give a better idea how to affect those factors. This modal choice between PT, car or other modes depends on some individual factors as age, income, household composition etc., but also on factors of the environment of the neighborhood(van Wee et all, 2002)(Schwanen & Mokhtarian, 2005). This could be the neighborhood of the living place but also of the working place and even the environment among the trip. It is important to see that modal choice will depend on different geographical levels(Schwanen et all, 2004). Especially the factors which are not at an individual level are interesting for policymakers, because with these factors they can work. If they can adapt their activities in the right way and change the environment of the neighborhood, these activities can possibly help to attract people from the car to PT.

However an recent report found out that it is very difficult to attract people from car to the PT, only under some circumstances there is a chance that people will change the car for PT (Kennisinstituut voor Mobiliteitsbeleid, 2015). Only with high parking tariffs/ parking problems and a high qualitative PT on the route people are willing to switch mode. For scientist it is interesting to investigate these factors to really understand the driving forces of modal choice behavior for commuting: is this mainly due to individual factors or is the neighborhood a more important factor, with factors as parking problems/tariffs and quality of the PT? Schwanen et all(2004) investigate neighborhood factors like density and ratio of jobs in a mixed-effects model, but using parking tariffs and quality of the PT as factors in a mixed-effects model is still not investigated as far as known. Therefore the following research question is created:

How do parking tariffs and quality of the PT of municipalities of the working place affect the use of Public Transport in commuting?

In this research the focus is on the factors parking tariffs and quality of the PT in municipalities. To what extent do these lead to less or more use of PT services? If for example parking tariffs are higher in a municipality than in another one the expectation is that people are less attractive to use the car, because of its higher costs. Then the expectation is that the PT use increases. And if the quality of the PT is higher in a municipality the expectation is that there is more use of PT services. Further focus in this research is PT-modes versus the car. This is only competitive when the travel distance is long enough(Kennisinstituut voor Mobiliteitsbeleid, 2015). Then slow modes are not favorable anymore, so the focus is only on PT-modes and the car. To specify the research question into parts three sub-questions are created:

1.To what extent do parking tariffs in municipalities of the working place affect the use of Public Transport in commuting?

2. To what extent do the quality of the PT in municipalities of the working place affect the use of Public Transport in commuting?

3. Is the effect of quality of the PT on the use of PT in municipalities of the working place strengthened by the presence of parking tariffs?

To give a answer on the sub-questions and research question a mixed-effects logistic regression is used with two levels. At the first level are variables which are all about people's characteristics like age, income, household composition and so on. The data comes from the OViN database. This data gives information about movements of people in a particular day(Centraal Bureau voor de Statistiek, 2014b). The focus in the modeling is on people which have a movement to their working place from their living place; the so called commuting people. In the second level of the regression the variables are about the municipality where this working place is settled. Most data of the local municipalities are found on the CBS database(Centraal Bureau voor de Statistiek, 2014a). Data of the parking tariffs is coming from the Nationaal Parkeer Register(Nationaal Parkeer Register, 2016). More information about the model and data would be described in the methodology part.

In the first part of this paper earlier research about the subject would be explained in the theoretical framework. After explaining the methodology the results would be displayed and an explanation about the results would be given. Hopefully a answer on the questions can be given in this part. At the end of the paper the conclusions, limitations of the research and recommendations for further research would be discussed.

Theoretical Framework

In this chapter the literature behind the research question is discussed. This literature comes mainly from scientific fields like geographic -, infrastructure - and transport economics. First thing discussed is some general information about the mode choice of people. Then is discussed which factors affect the choice of mode, respectively personal characteristics, preferences of people, land use factors and PT-service levels. Not all the sources are focusing on commuting, but also on the use of PT in general. Also from these general sources important factors can be derived, because the use of PT in general and commuting may lie close to each other. If there are differences between them this will be highlighted in the text.

Mode choice

In the past the choice of transportation mode has been under investigation. The choice of mode is usually seen as an application of consumer choice theory, which means that the consumers, in this case the people who wants to travel, make a rational decision for the mode which give them the highest utility(Domencich & McFadden, 1975)(Ben-Akiva & Lerman, 1985). The utility of a mode is basically a function of what a individual basically get when using that mode and the travel costs. What a individual get is for example which kind of chair, how many space around chair, the possibility to listen music etc. Travel costs included monetary costs as well as time costs. Monetary costs for a car are for example fuel, insurance costs or taxes. For PT use this is the price of a ticket. Time costs are simply the time which is needed for the trip. If what a individual get using a certain mode is lower or the travel costs are higher this mode gain less utility than modes with higher prices and/or lower travel costs. What individuals get using a certain mode can influence the choice of mode(Ben-Akiva & Lerman, 1985). For example the possession and use of a car is positively related with a feeling of authority and self-esteem (Ellaway, Macintyre, Hiscock, & Kearns, 2003). Reasons as health and the environment are more in favor for modes as bicycles or PT (Hopkinson & Wardman, 1996). Many policies are interested in a switch from car to PT modes for reasons as environment and traffic congestion(Banister, 2008). To increase the percentage of PT car users need to be convinced to use PT modes. While there are arguments that people use their car out of necessity, some people drive the car by choice(Handy et all, 2005). To shift these people from the car to other modes policy measures are needed. There are some factors which are important in this modal choice between car and PT. These factors will be discussed in the next paragraph, but first some extra information about commute mode choice will be discussed.

The focus in this research is on commuting so some differences between commuting mode choice and normal mode choice will be highlighted. In commuting less people are using PT in comparison with the average of all the PT trips in the Netherlands(Centraal Bureau voor de Statistiek, 2015d). One reason is that students are highly represented in PT use. Furthermore commuting is different because the role of the employer is very important. The location, parking availability, work schedules and mobility management measures have a significant effect on the choice of the employees to choose for the car or PT (Vanoutrive et all, 2010). Furthermore it is important to see that using the PT is more attractive on longer distances, because with short trips the car has faster travel times, which also applies to commuting(Kennisinstituut voor Mobiliteitsbeleid, 2015). So people are only making a choice between PT and car if the commute distance is long enough. Even more they must have access to PT from their living place to their working place(Schwanen & Mokhtarian, 2005). If there is a mismatch the car could be their only possible solution to commute.

Personal characteristics

In the previous section is discussed that what a individual get using a certain mode influences the mode choice. But each individual is different and gives different values to what they get and the travel costs. These differences in taste can be represented by the personal characteristics of each individual. Personal characteristics are mainly represented by socioeconomic and demographic variables, like age, income, gender, household composition or car availability(Cervero, 2002)(Schwanen & Moktharian, 2005). Looking at income US residents with a low income are more dependent on PT modes than residents with a higher income, which may be explained by the high costs for buying and keeping a car(Limtanakool et all, 2006). But when car ownership is saturated income will have a slightly positive effect on PT demand in the United Kingdom(Paulley et all, 2006). Looking to gender it looks like men prefer PT more than women do(Patterson et all, 2005). Explanation could be that women need more trips, because of family life reasons and so have a more complex travel pattern, which is unfavorable for PT. The feeling of being safe in PT modes comparing with the car could be another explanation. For the household composition it appears that households without children have a higher percentage of using PT modes(Srinivasan & Ferreira, 2002). With children more trips needed to be made and this is in favor for the car. Other reason could be that people without children live in other neighborhoods than people with children when PT is for example better accessible. Already mentioned before is that number of stops a person is making on a trip and time travel reliability is affecting the mode choice of people(Bhat & Sardesai, 2006). If a person have more activity stops during his commuting trip it is more likely that this person is using a car(Bhat, 1997). What is also often seen in literature is the effect of car ownership on mode choice. If a household owns a car or more cars the choice for driving the car is increasing(Bhat& Sardesai, 2006)(Pinjari et all, 2011). Of course this sounds very logical, because if a person don't own a car he can't drive with it. Underlying factors could play a role, for example a person's income. If income is higher it is more likely that there is money for buying a car. For having a drivers license also applies that it has a positive effect on using a car(Zhang,2004)(Bhat & Sardesai, 2006), without a license it is not justified to drive for people. Also researched is the influence of age on mode choice. If people are older they are more likely to choose the car(Zhang, 2004). Even in the case of commuting older workers are less likely to take the bus in the case of Los Angeles(Schwanen & Moktharian, 2005). The reason could be that older people have saved more money and are able to buy a car at a higher age, which could be explained by income. Older people could also value the safety and comfort in their own car higher than for other modes with other people around them. Last discussed personal characteristic that is been used in mode choice research is educational level. However educational level is not used many times in research, it is associated with mode choice(Chatman, 2003). Higher educated people are mainly richer so they could have more money to buy a car. It is clear that the characteristics discussed above are important in choosing a mode, but the reasons behind these characteristics are not always obvious. Some characteristics can influence each other, for example the relations between income, car ownership and age. Good examples are given in the research of Paulley et all(2006) about the effect of income and car ownership on PT use. Four different relationships are described.

• An increase in income will, depending upon the level of income, lead to an increase in car ownership and so car availability, or to an increase in PT use.

• An increase in car ownership will, other things being equal, lead to a reduction in the demand for public transport modes.

• The sign and magnitude of demand elasticities for public transport with respect to car availability and income will vary depending upon the income levels.

• Income growth can be expected to increase average trip length.

This example shows that it is hard to found the causality in this kind of relationships. Nevertheless in almost every study about mode choice personal characteristics are used in the models to predict how individuals values the different modes.

Preferences

At a later stage in time a more psychological influence towards mode choice is introduced. There was more investigation about the feelings and beliefs towards a mode and the influence of this on mode choice. Perceptions about convenience and service levels together with beliefs and feelings about a certain mode decided which mode would be chosen, which differs from the research discussed above where is stated that the mode characteristics and personal characteristics decided which mode will be chosen(Koppelman & Lyon, 1981). For example: two people can have exactly the same personal characteristics but their perceptions and feelings about a certain mode are different, which lead to another mode choice. Some evidence of this is found in the research of Kitamura(1997), where is found that the share of the car in total number of trips is positively related to attitudes to the car and the PT. Furthermore a study by the consultant Muconsult(1994) concluded that preferences and attitudes towards modes made up 40% of the explanatory power, 40% by personal variables and 20% by land-use and infrastructure variables. Interesting difference in the research of Scheiner & Holz-Rau(2007) is that they stated that mode choice is more affected by life situation than by lifestyle. So this could be explained that the location characteristics are more important for choosing a mode than a specific lifestyle can do. But on the other hand lifestyle is important in choosing a place to live which in turn affects mode choice. So the whole concept of psychological factors looks important, therefore studies include this psychological part. Using this psychological concept in a detailed way can give a lot of lifestyle - and attitudinal factors to determine the effect of mode choice, which is done in a study of Bagley & Mokhatarian(2002). To found lifestyle and attitudinal factors for individuals questions about there preferences must be asked which is usually not done in big mobility datasets.

Land use

In the past 15 years more and more research is done about the influence of land use and infrastructure provision on the mode choice of people(Schwanen & Moktharian, 2005). For policy significance these kind of research is more interesting, while planning strategies and design features could be used to reduce the use of the car and improve PT or other modes(Crane, 2000). Especially with the increasing importance of sustainable transport and environmental question in general this kind of research became more popular. In the following section some literature about this subject will be explained.

In literature density appears to be a important land-use variable to explain mode choice. Cervero(1996) found that workers are more likely to go by PT if there are shops nearby, if there are more houses per km^2 or if they live in the central city. The idea is that they can go to the shop walking from their workplace and then go back to home with the PT. So they don't need a car anymore to go to the shops. Also an interesting finding from this research is that people live in dense areas are more likely to make short commute trips by PT. An explanation could be that people in more dense areas have less cars, so even don't have the choice to go by car. This is another insight to focus on longer commuting trips in this research, because then there is actually a choice between car and PT. Equal to the research of Cervero (1996) there are more researchers which are using land use variables to look at commute mode choice. Chatman (2003) found out that employment density has a positive influence on the use of PT. For policymakers this could be an incentive to create more dense business districts, where people are more sharing cars or use the PT. To build further on the density variable Cervero & Gorham(1995) found that PT-oriented neighborhoods in Los Angeles generate more pedestrians and use of PT than their automobile-oriented counterpart. In their research PT-oriented neighborhoods are defined as neighborhoods initially built along a streetcar line or a rail station, with a lot of four-way road intersections and largely built before 1945, while automobile-oriented neighborhoods are defined as neighborhoods with little access to PT, random street patterns and built after 1945. The result only applies for the more centralized neighborhoods in Los Angeles, so the more dense neighborhoods. The results are not contradictory and the lack of a good methodology could be the reason. For example the used neighborhoods which are marked as PT-oriented have lower incomes on average, which can be the main reason of higher use of PT modes in this kind of areas. Furthermore it sounds very logical that there is more use of PT in PT-oriented neighborhood, because of the lack of PT accessibility in their automobile counterpart. Cervero & Gorham(1995) also stated that the density of the area was negatively related with car use, because more dense areas are including on average more transit services, more local shopping and have a pedestrian friendly environment. This last relationship is also found in the research of Messenger & Ewing(1996), but they also found a relationship with car ownership. In more dense areas the car ownership was lower, which is also shown in research of Cervero(1996). This could be a reason why more dense Los Angeles neighborhoods generate more pedestrians and PT use, instead of that they are PT-oriented. It therefore appears that density is a complex variable to explain mode choice, because it is hard to find the causality(Cervero & Gorham, 1995)(Wee et all, 2002)(Schwanen & Mokhtarian, 2005). Do people choose PT because there neighborhood is dense or are people who don't prefer the car living in dense areas? Another land-use factor could be the influence of P&R locations on mode choice. Wang et all(2004) researched the influence of P&R locations and pricing. In his research is shown that the presence of a P&R location drops the modal share of the car on the highway. So less cars are used to access the centre of the city.

PT-service level

Besides land use variables PT-service level variables are also playing a role in mode choice. Determining the preferences towards a certain mode the service level of the mode can be used(Bhat, 1998). The frequency or reliability of the mode can be used as a proxy for the service level. If the frequency or reliability of a mode is higher the expectation is that travelers have a higher preference for that mode. Holtzclaw(1994) found a negative significant relation between PT accessibility and car use. Here PT accessibility is measured as the amount of PT vehicles per hour in that particular neighborhood. So if there are more PT vehicles accessible in the neighborhood the car use is decreasing. Even more PT-service level variables can act as proxy's for land use variables as density. This is investigated in research of Pinjari et all(2011). In this research some modal accessibility variables, as proximity to local zones within 30 minutes or bicycle facility density, are added to their research on modal choice. After adding these variables land use variables as household density or employment density became less significant or even not significant, what suggest that land use variables act as proxy's for modal availability and accessibility. What Pinjari(2011) also found is that these modal accessibility and availability are important at the living place and work place simultaneous. This means that policy makers have to improve the modal accessibility and availability at both the living place and work place. So this means there is actually a difference between respondents who can really switch mode because they have the option and respondents who can't because it is not possible for them. Policymakers can improve the PT so that respondents have really the possibility to switch mode or make it hard for respondents to use the car on the other hand. Therefore Chatman (2003) recommend further research on parking prices, road congestion and transit services, because he suspect that the common significant variable density in these kind of researches act as a proxy for underlying variables as parking prices, road congestion and transit services. So for example lower parking prices, which are commonly lower in less dense areas, has the effect that more people are using the car. This is supported by the finding that only higher parking prices and a better PT quality will switch people from the car to the PT(Kennisinstituut voor Mobiliteitsbeleid, 2015). In this literature study of different sources from different countries elasticity's for Dutch travelers are estimated. From this it follows that the car users and PT users are separated markets. Probability of interaction is highest when using the car becomes problematic with high parking rates, long search times for parking space and high congestion. Also Hess(2001) found out in a multinomial study that free parking around the work place has an effect on the choice between car and PT. Free parking will encourage people to drive alone, while rising parking costs give a increasing probability to switch them to PT.

This research tries to combine these factors to found out which effect these factors have on commuting mode choice. More detailed: with the use of variables as parking prices, congestion figures and PT frequencies the goal is to find out if these factors at the workplace have a significant effect on the mode choice between car and PT. This could be very interesting for policymakers, because parking prices and PT frequencies are much more easily to change in a short time than for example neighborhood densities. The two-level model also uses control variables at the socioeconomic and demographic level which are discussed above.

In table 1 all the possible influences on mode choice are listed. Also the expected relation is given with a +, - or +/-. Here the + indicates a positive expected relation between the variable and the use of PT modes. The - indicates a negative expected relation and a +/- indicates a uncertain or complex relation. Some of these variables cannot be measured in this research. First is the mobility management factor. In the data no information is given if there is an involvement of mobility management measures. Their influence could be underestimated in the results. Furthermore the reliability of the PT modes is difficult to measure. This research is going to use frequency figures as a proxy for PT quality, however reliability data is not available in the datasets. This could give a bias in the results if for example frequencies are high but reliability is low. Then PT quality could be overestimated. The lifestyle- and attitudinal factors are also difficult to measure, because of their complexity. In the section 'PT-service level' is described that the service level of a mode can be used to determine the preferences of respondents.

Table 1: Factors from literature

Location of the Workplace	+/-
Parking Availability	-
Commuting in peak times	+
Trip Distance	+
PT Availability	+
Income	-
Car Ownership	-
Being a man	+
Larger household	-
Higher educated	-
Drivers License	-
Number of Stops	-
Travel Time	+
Reliability	+
Age	-
Frequency PT	+
Lifestyle- & Attitudinal Factors	+/-
Density	+
Employment Density	+
PT Accessibility	+
Parking Prices	+
Road Congestion	+
PT Quality	+

Data & Methodology

To give an answer on the research question statistical models must be made to predict the eventual effects of the variables. Therefore data is needed and a idea how to build these models must be discussed. In the first part of this chapter a description of the data will be given. Where does the data come from and how is it structured? In the second part of this chapter the methodology would be explained.

Because the data only covers the Netherlands a look to some characteristics for this county is needed. Taking a look to the use of PT across Europe the Dutch people are travelling by train above European average in 2012(Treinreiziger.nl, 2013). The average Dutch resident is travelling 21 times a year by train and travels a distance of 1024 kilometers. In statistics of the CBS(2015c) is found that people who are actually using the train or other PT modes are mainly between 15 and 30 years old. Many of them are students, which own a Student PT-card. Also people with a lower income are more frequent users of the PT. In the case of gender women are slightly larger users in the Netherlands. In generalizing the results all these characteristics of Dutch travelers must be taken into account.

Data

For this research data of different sources is used. There is data from the OvIN dataset, data from the KiM and furthermore data from the CBS. They will be discussed one after another.

OViN

The OViN dataset, performed by the CBS in the Netherlands, collects data about the movements of people(Centraal Bureau voor de Statistiek, 2014b). For this dataset persons in the Netherlands are questioned about their movements in one day. The questionnaire is taken out in three phases. A first sample of individuals in the Netherlands get the questions by internet. If there is no response a telephone approach will follow. If there is no telephone response the third phase starts, which are face-to-face interviews with the respondents. The questions are about their destination, how long the movements take, about the modes they using, the distance of their movements, the motive of their movements etc. This kind of data is completed with personal characteristics from each person like age, household composition, living place, working place and so on. Together this dataset has 553.952 observations. Not each observation is one person, because one observation represents one movement at that day. So for example from home to work. But also possible is from home to the bus station as first movement and then from the bus station to work as second movement. In the dataset multiple observations from the same person are excluded by picking the movement with the longest travel time. The OViN dataset forms the basis of the total dataset which is used for this research and would be complemented with data at municipality level.

The variables this research is going to use from the OViN data are control variables at the first level. First there is the age of the respondent. This is a continuous variable, which is common. Sometimes age can be divided in different age groups, to see differences between the groups. For the research question in this research it is not interesting to do that. Second variable is the household composition where the amount of persons per household would be used. In other research also types of household composition are used(Srinivasan & Ferreira, 2002)(Schwanen & Mokhtarian, 2005). In this research the choice is for a continuous variable, because a categorical variable with too much categories could be a problem when each category has to less observations. Zhang(2004) has also used an continuous household variable in his research on travel mode choice. Next control variable is the gender of the respondent. This could female or male, where female is coded as 0 and male as 1. Also educational level will be used, this is a dummy variable with as most important outcomes lower vocational education, intermediate vocational education and higher vocational/university educated respondents. After coding all other possible outcomes than these degrees of education the variable has 4 categories. They are coded as follows: 0 is higher vocational educated/university, 1 is intermediate vocational educated, 2 is lower vocational educated and 3 is all other possible outcomes. While a lot of researchers ignore educational level it could be interesting what the effect is on commute mode choice. Also income will be used in the models. In this case the standardized disposable income in 10% groups are used. This means that all the respondents are classified in one of the ten subgroups of income. The income variable is considered as a continuous variable for the same reason as the household variable. The variable car ownership gives information about how many cars the respondent own in his household and is also a continuous variable. This is in almost every study the same like the studies of Schwanen & Mokhtarian(2005), Zhang(2004) and Pinjari et all(2011). Furthermore there is data if the respondent owns a driver license, which is simply a yes or a no. In possession of a drivers license is coded as 1 and no possession is coded as 0. The number of movements of the respondent could also be an important variable. It gives information about how many movements are made in one day and so it is a continuous variable. The one but last first level variable used from the OViN dataset is travel time. This is the time in minutes the respondent needed for his trip and is included in almost every study about mode choice. The last variable is departure time. Here a dummy variable is created which shows if people are leaving in peak time or otherwise. Peak time is defined as departure times between 7 and 9 in the morning. If this is the case it is coded as 1. If the departure time is outside this time range it is coded as 0. This kind of variable is not very common yet, but other researchers try to do the same in different ways. Schwanen & Mokhtarian(2005) made a dummy if people are driving in the night or during the day, where during the day is supposed as peak times. Pinjari(2011) created a dummy when people have a inflexible work schedule, so supposed that they have to travel in peak times. The dummy created in this research is more advantaged, because it is more precise than the other two options mentioned above.

Municipalities

A part of the second level data comes from 'Kennisplatform CROW'(CROW Kennisplatform Verkeer en Vervoer, 2016). This institution collects data in the Netherlands from different sources like CBS and 9292OV about mobility and infrastructure. In this research different datasets from 'Kennisplatform CROW' on municipality level is put together. For example data about the PT availability and frequencies or data about P&R locations. Most of this data is from 2014. Some also about a period from 2010-2013 or 2015. If this data is put together with the OViN data there could be some difference about the year from the observations in the OViN dataset and the observations at municipality level, because of its cross-section structure. Of course this is not perfect, but assuming that the municipality data is not changing in a fast way it would be acceptable.

The first part of the municipality data described above is completed with some extra data from the CBS. Mainly some basic information about each municipality is added. For example information about the size, density and parking availability of a municipality. This data is taken at the year 2014.

After putting all the municipality data together there is data for 418 municipalities available. In reality there are less municipalities than 418 at the moment in 2015. The reason why is that in the Netherlands a process is going on that small municipalities near each other are going to collaborate and working further as one. That explains that there is data from 2010 till 2015 of some municipalities that actually doesn't exist anymore at this moment. This problem concerns only about 20 small municipalities so this would not be a big problem for the analysis.

The following described variables of this dataset are expected to be used in the analysis. The most important is the PT-frequencies in a municipality, which is one of the variables of interest. The recommendation of Chatman(2003) to investigate the impact of PT services is followed, PT-frequencies here act as a proxy for the quality of the PT. The PT-frequencies are defined as the highest week frequency of a certain municipality. The data gives the number of leaving rides in the municipality in one week of bus, tram and metro lines. Train frequencies are not taken into account in this number, which could lead to an over-or underestimation of the influence of PT-frequencies on modal choice. Maybe train frequencies has a higher impact on modal choice than busses, trams and metros. In that case the total impact of PT-frequencies is underestimated. Furthermore congestion figures of the municipality are used. More specific the figures are an indicator of the travel time plotted against the expected travel time at straight line distance. Figures higher than 100 display longer travel times and number lower than 100 display smaller travel times than expected. This figure is described as an 'accessibility indicator', because a high figure indicates more congestion so less accessibility and vice versa. Also expected to be used is the number of P&R locations in an municipality. In fact this is not the number of P&R locations itself but the total amount of spaces at all the P&R locations per municipality divided by the amount of residents. Then this number is multiplied by 1000. So this variable is formulated as P&R spaces per 1000 residents. Due to all the attention in literature about the effect of density this variable is also taken into account. In this research density is calculated by dividing the total amount of residents in an municipality on the surface of that municipality. So density is formulated in residents per square km. Last variable is the percentage of jobs without access to PT services in 2013. An employee has access to PT services when there is a train station in 2km, a metro station in 1km and/or a bus - or tram station in 0.5km given the infrastructure. The percentage of employees which meet these requirements is used as variable. Pinjari(2011) used an accessibility variable where is calculated how many zones can be reached within 30 minutes by PT. In this research the focus is on commuting so the variable used in this research sounds better.

Parking Tariffs

Data about parking tariffs comes from the NPR(Nationaal Parkeer Register, 2016). The NPR is a national database in the Netherlands which combines data about parking services of municipalities and private companies. Here is also data included about the parking prices of each parking garage. For the analysis the data about the parking rates are used. With these parking rates data the findings of the Kennisinstituut voor Mobiliteitsbeleid(2015) and Hess(2001) can be tested. In short they stated that higher parking rates encourage to switch mode.

For this research only the public garages are included. The focus is on what policies can change in commuting modal choice between PT and car, this is easier to achieve with public garages. Of course policy makers can influence private parking garages, but in a more difficult way. For example negotiations are needed to convince private parking garages to raise or drop parking rates. Therefore the focus is on public garages in this research. The dataset consist of 4407 observations of public parking garages. For each municipality the public parking rates are combined and an average rate is calculated. The parking rates range from 0 till 9 Euros per hour. About 800 parking garages are freely accessible. After calculating each municipalities average the range is from 0 to 3.36 Euros per hour per city. Hess(2001) used the costs of parking for a 8 hour work day. If needed this is comparable with the variable used in this research by multiplying it with 8 times.

Selection making

Before building the models the right data must be selected, because the total dataset is too wide for answering the research questions. This research focus is on commuting people which go from home to their work by car or PT. Therefore only individuals are selected which have as motive for traveling: 'From and to work'. Further selection is made by keeping the rides to the working place. Now the dataset only contains commuting people to the working municipality.

A further selection is made by focusing on car versus PT-modes. All other modes like the bicycle or by foot are removed. Next a new variable is made, namely the modal choice variable, which would be also the dependent variable in this research. It is a binominal variable which made the distinction between car users and PT-users on the other hand.

Whereas the Kennisinstituut voor Mobiliteitsbeleid (2015) found out that there is only a choice between car and PT if the trip is long enough there is a need to focus on longer trips. This also strongly justifies why other modes are removed from the selection. Most long trips are made by car or PT and not by bicycle or by foot. Therefore there is a concentration on commuting trips longer than 7,5 Km. In the Netherlands around 50% of all the trips made are shorter than 7,5Km(Kennisinstituut voor Mobiliteitsbeleid, 2015). For this kind of distance it is unfavorable to take the PT, because it takes too much time in comparison with the car of bicycle.

Now the final dataset gets his form there is still a problem. There are still individuals with multiple movements in the dataset. To bring this back to one movement per individual the movement with the longest travel time is selected.

After checking for outliers for each variable the only variable where are outliers found are in the age variable. There were 34 observations where the respondents age is lower than 18 years old. At this age it is not possible in the Netherlands to have a 'real' job, so this justifies why these 34 observations are dropped. The final database is now selected and consist of 21.323 observations.

In table 2 the descriptive statistics of the used variables are listed and in table 3 the correlation matrix is shown. The modal split is as follows: around 14% of the respondents in the dataset is using the PT and the other 86% is using the car for their movement to the working place. Also good to see is that around 97% of the respondents is in possession of a drivers license, which has a correlation of 0.43 with the dependent variable. In the correlation matrix a high correlation of 0.69 between travel time and travel distance is discovered. Therefore the choice is made to exclude one of these in the models, namely travel distance. Furthermore the second highest correlations are between the second level variables, but these are not frightening for the making of the models.

Table 2: Descriptive Statistics

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
ModalChoice	21323	0.1390517	0.346009	0	1
Household Composition	21323	2.891526	1.297579	1	10
Gender	21323	0.600197	0.489869	0	1
Age	21323	42.27318	11.96057	12	91
Education level	21323	0.7823477	0.80633	0	3
Income	21282	6.437412	2.659004	1	10
Drivers License	21303	0.9686899	0.174159	0	1
Car Ownership	21319	1.636521	0.825308	0	9
Number of Movements	21323	3.334381	1.727331	0	15
Peak Time	21323	0.5523144	0.497267	0	1
Travel Time	21323	101.8551	72.79543	0	1945
Density	20494	6098.548	11806.9	11.98933	40883.96
Congestion	20189	98.15192	7.439351	45.0887	145.383
P&R	20494	5.36695	4.873047	0	29.14883
PT-Quality	20684	4561.036	4499.789	120	20546
Jobs without PT-accessibility	20684	0.1890256	0.141594	3.69E-05	0.672784
Parking Tariff	21323	0.7548422	0.631641	0	3.363333

Table 3: Correlation Matrix

	ModalChoice	Household Composition	Gender	Age	Education level	Income	Drivers License	Car Ownership	Number of Movements	Peak Time	Travel Time	Travel Distance	Density	Congestion	P&R	PT-Quality	Jobs without PT-accessibility	Parking Tariff
Modal Choice	1.00																	
Household Composition	-0.06	1.00																
Gender	-0.07	0.06	1.00															
Age	-0.09	-0.11	0.10	1.00														
Education level	-0.07	0.00	0.05	0.07	1.00													
Income	-0.03	-0.06	0.00	0.19	-0.24	1.00												
Drivers License	-0.43	0.04	0.07	0.09	-0.06	0.09	1.00											
Car Ownership	-0.31	0.34	0.05	-0.04	0.01	0.24	0.21	1.00										
Number of Movements	-0.07	0.04	-0.10	0.00	-0.09	0.01	0.05	0.03	1.00									
Peak Time	0.01	0.00	-0.11	-0.05	-0.18	0.09	0.02	0.01	-0.03	1.00								
Travel Time	0.23	-0.03	0.06	0.02	-0.12	0.06	-0.08	-0.06	0.28	-0.08	1.00							
Travel Distance	0.02	-0.00	0.17	0.03	-0.13	0.10	0.04	0.05	0.15	-0.13	0.69	1.00						
Density	0.30	-0.02	0.00	0.00	-0.08	0.06	-0.10	-0.12	-0.03	-0.00	0.13	0.04	1.00					
Congestion	0.24	-0.04	0.02	0.00	-0.07	0.10	-0.09	-0.11	-0.03	-0.02	0.13	0.03	0.47	1.00				
P&R	0.03	-0.01	-0.02	0.02	-0.04	0.01	-0.01	-0.02	-0.01	0.02	0.03	0.03	-0.06	-0.12	1.00			
PT-Quality	0.27	-0.03	-0.01	0.01	-0.09	0.09	-0.08	-0.11	-0.03	0.00	0.14	0.07	0.48	0.44	0.09	1.00		
Jobs without PT-accessibility	0.12	-0.01	0.00	-0.00	-0.02	0.02	-0.04	-0.06	-0.02	-0.02	0.05	0.02	0.37	0.29	-0.20	0.13	1.00	
Parking Tariff	0.12	-0.01	-0.01	0.01	-0.07	0.06	-0.03	-0.05	-0.02	0.01	0.07	0.06	0.05	0.03	0.25	0.28	-0.13	1.00

Methodology

To find an answer on the research question a mixed-effects logistic regression is used with two levels, the first level is an individual level with personal and trip characteristics of each respondent. The second level is on municipality level with some characteristics of the municipality where the respondents are working. The two variables of interest are PT-frequencies and parking tariffs, which are both second level variables. Besides these variables some control variables are used which are separated in first level and second level variables.

Model making

The mixed-effects logistic regression implies that there is made a distinction between a fixed part and a random part. The systematic relationship between the dependent variable and the explanatory variables is represented by the fixed part. This part includes the intercept and the regression coefficients. The variation around this fixed part is represented with the random part coefficient(Bullen, Jones, and Duncan 1998). Because of the nested structure of the data with the two levels there is dependency of observations. Using a mixed-effects logistic regression can deal with this problem by the extension of the random part of the regression(Schwanen et all, 2004). The models used in this research are all random intercepts models which assumes that slopes are fixed. Because the independent variable is binary a logistic regression is made. The results of the logistic models only gives information about the sign of the effect of the variable. To say something about the size of the effect the marginal effects must be calculated. So for each model the average marginal effect would be calculated, which can be found in table 5. In fact it's more precise to predict the marginal effects for a specific value, but for a general view of the effect the average marginal effects is much easier. Otherwise hundreds of specific values have to be compared. That takes a lot of time and it's hard to compare all of them. So the average marginal effect is more convenient to give a general view of the effects. But the average marginal effects can't be calculated for models which have a fixed and a random part like the mixed-effects logistic regression in this research. Therefore only the predicted probability of the fixed part of the models would be calculated. This is where this research is interested in, so there is no further need to calculate the predicted probabilities of the random part of the model. Below a short description of each model is be given.

The first model is a model where only the two variables of interest are included, which are the second level variables parking tariffs and PT-quality. This could be interpreted as a basic model where can be shown if the variables have an effect or not. In the next models where more control variables are added the effect of these variables on the variables of interest can be derived.

Model 2 uses PT-quality and all level 1 control variables. The control level 1 variables are household composition, gender, age, educational level, income, drivers license, car availability, number of movements, departure time and travel time. Only one variable of interest is used in this model.

In model 3 the other variable of interest parking tariffs are also added to the model. When comparing the models 1, 2 and 3 the effects of the variables of interest on the explained variance can be derived separately. It seems that it could be calculated in a easier way, when for example a model with all level 1 variables and two models with all level 1 variables and both variables of interest. But the statistical program was not able to calculate a mixed-effects logistic regression with only the level 1 variables. And it was also not able to calculate a model with all level 1 variables with a add of the parking tariff variable. So with some creativity in the model making the desired results can still be achieved.

Before answering the sub-question 1 and 2 also the control variables of the second level must be included to the model. This is happening in model 4 where the percentage of jobs without access to PT services, P&R availability, congestion and density are added.

For answering sub-question 3 the interaction variable between parking tariffs and PT-quality are added. This would be the fifth model. The outcomes of the five models are represented in table 4, which will be discussed in the next chapter.

Table 4: Models

	Model 1	***Model 2***	***Model 3***	***Model 4***	***Model 5***
_cons	-3.355***	4.806***	4.658***	0.0512	-0.00503
	[-38.82]	[13.61]	[13.13]	[0.07]	[-0.01]
Household Composition		0.194***	0.194***	0.191***	0.191***
		[8.83]	[8.81]	[8.66]	[8.67]
Male		-0.525***	-0.523***	-0.517***	-0.517***
		[-9.37]	[-9.35]	[-9.21]	[-9.20]
Age		-0.0180***	-0.0180***	-0.0174***	-0.0174***
		[-7.38]	[-7.36]	[-7.12]	[-7.12]
Intermediate Education		-0.250***	-0.248***	-0.246***	-0.246***
		[-4.06]	[-4.03]	[-3.98]	[-3.98]
Lower Education		-0.538***	-0.536***	-0.568***	-0.567***
		[-5.35]	[-5.32]	[-5.59]	[-5.58]
Other		-0.398*	-0.393*	-0.373*	-0.373*
		[-2.26]	[-2.23]	[-2.11]	[-2.11]
Income		0.0697***	0.0696***	0.0672***	0.0672***
		[5.99]	[5.99]	[5.76]	[5.77]
Drivers License		-5.889***	-5.892***	-5.775***	-5.773***
		[-18.37]	[-18.40]	[-18.29]	[-18.30]
Car Ownership		-1.714***	-1.713***	-1.708***	-1.709***
		[-32.61]	[-32.61]	[-32.38]	[-32.39]
Number of Movements		-0.268***	-0.267***	-0.264***	-0.263***
		[-13.87]	[-13.85]	[-13.61]	[-13.61]
Peak Time		0.134*	0.132*	0.138*	0.138*
		[2.38]	[2.34]	[2.44]	[2.44]
Travel Time		0.00929***	0.00926***	0.00914***	0.00914***
		[24.10]	[24.03]	[23.62]	[23.61]
Parking Tariffs	0.322***		0.354***	0.436***	0.497***
	[3.54]		[3.71]	[5.31]	[4.22]
PT-Quality	0.000159***	0.000167***	0.000144***	0.0000930***	0.000111***
	[8.68]	[9.46]	[8.23]	[6.82]	[3.92]
Jobs without PT Accessibility				0.691	0.625
				[1.92]	[1.69]
P&R				0.0416***	0.0419***
				[4.18]	[4.23]
Congestion				0.0433***	0.0436***
				[6.31]	[6.36]
Density				0.0000278***	0.0000272***
				[3.90]	[3.84]
Interaction					-0.0000213
					[-0.73]
var(_cons)	0.449***	0.413***	0.367***	0.152***	0.149***
	[-4.99]	[-4.76]	[-5.12]	[-6.48]	[-6.46]
Log lik.	-7178.8	-4855.5	-4848.9	-4740.3	-4740.0
N	20655	20616	20616	19992	19992

t statistics in brackets
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Marginal Effects

	Model 1	***Model 2***	***Model 3***	***Model 4***	***Model 5***
Household Composition		0.01156***	0.01176***	0.01291***	0.01291***
Male		-0.03212***	-0.03269***	-0.03582***	-0.03575***
Age		-0.00107***	-0.00109***	-0.00118***	-0.00118***
Intermediate Education		-0.01516***	-0.01536***	-0.01698***	-0.01696***
Lower Education		-0.03031***	-0.03075***	-0.03647***	-0.03636***
Other		-0.02328*	-0.02342*	-0.02505*	-0.02500*
Income		0.00415***	0.00423***	0.00454***	0.00454***
Drivers License		-0.76113***	-0.76215***	-0.72833***	-0.72826***
Car Ownership		-0.10197***	-0.10398***	-0.11546***	-0.11533***
Number of Movements		-0.01592***	-0.01621***	-0.01781***	-0.01778***
Peak Time		0.00794*	0.00797*	0.00931*	0.00929*
Travel Time		0.00055***	0.00056***	0.00062***	0.00062***
Parking Tariff	0.02813***		0.02147***	0.02946***	0.03357***
PT-Quality	0.0001***	0.00001***	0.00001***	0.00001***	0.00001***
Jobs without PT accessibility				0.04672	0.04220
P&R				0.00281***	0.00283***
Congestion				0.00293***	0.00294***
Density				0.00000***	0.00000***
Interaction					-0.00000
N	20.655	20.616	20.616	19.992	19.992

t statistics in brackets
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results

After running the models the first model shows the model with only the variables of interest, namely parking tariff and PT-quality. Both variables are positive and significant at the 0.1% level. If the parking tariffs in a municipality increases with 1 Euro the predicted probability of PT use increases for an individual with mean characteristics, ceteris paribus. The marginal effects tables shows that this is an increase of 2.813 percentage points. And if the PT-quality increases with 1 frequency per week in a municipality the increase in the predicted probability of PT use is on average 0.01 percentage points for an individual with mean characteristics, ceteris paribus. This gives a first evidence that both variables have a positive significant effect on PT use. In model 2 PT-quality and all the level 1 variables are added to the model. In model 3 both variables of interest and all the level 1 variables are included. This is to derive the effects on the explained variance of both PT-quality and Parking Tariffs. When comparing model 3 with model 1 the level 1 variables decreases the unexplained variance of the municipality level with (0.449-0.367)/(0.449)*100= 18.26%. The effect of Parking Tariffs on the unexplained variance can be derived to compare model 2 with model 3. The decrease due to Parking Tariffs is (0.413-0.367)/(0.413)*100= 11.14%. Now also the decrease due to PT-quality can be derived by calculating the differences. The decrease in unexplained variance at the municipality level by PT-quality is 18.26-11.14=7.12%. Interesting is that PT-quality and Parking tariffs are still significant and positive at the 0.1% level after adding the level 1 variables. These are in turn also significant at the 0.1% level, except peak time and other education level which are significant at the 5% level. Two variables will be interpreted as example, namely car ownership and educational level. Model 3 shows that an increase in car ownership with one car reduces the predicted probability of PT use on average with 10.398 percentage points for an individual with mean characteristics, ceteris paribus. This effect is significant at a 0.1% significance level. And being intermediate vocational educated, lower vocational or other educated compared with higher vocational/university educated reduces the predicted probability of PT use on average with respectively 1.536, 3.075 and 2.342 percentage points for an individual with mean characteristics, ceteris paribus. This effect is significant at the 0.1% level for intermediate vocational and lower vocational educational level and for other educational levels the effect is significant at the 5% level.

What is striking in model 3 is that some variables have another effect on PT-use than expected from literature(table 1). First of them is income, which is expected to be negative, because more income give the opportunity to buy a car. Paulley et all(2006) already described the difficult relationship between income and car ownership and their effect on PT use. So it is also possible that a higher income in general lead to more use of PT, because people can afford it now to travel or there is more demand for travelling. The correlation between car ownership and income is also one of the highest correlations between the first level variables, namely 0.24. This could also be an reason of the unexpected sign. This is also the case with household composition, where the correlation is 0.34 with car ownership. Household composition is positive, while the expected relationship on PT use is negative. That means that respondents living in a larger household are expected to make more use of PT than a respondent in a smaller household, if all other variables are equal. Third variable that is different than expected at the first time is educational level. But already indicated in the theoretical framework is that the relationship between educational level and PT use was still unclear. This research gives evidence that higher vocational/university educated respondents have a higher probability to use the PT compared with intermediate vocational , lower vocational or other educational levels. Last variable that is different than expected from literature is gender. In this research females are more likely to choose for PT. A possible explanation could be found with the help of Matthies et all(2002). Their results show that females have a greater willingness to reduce car use and prefer PT relatively more than male. This is mainly influenced by a higher ecological norm and weaker car habits. In the time this research is set up it could be that females indeed reduce their car use and choose relatively more for PT. But also already mentioned is that females are slightly larger users of PT in the Netherlands than males(CBS, 2015c). So this results could be a specific result for the Netherlands.

In model 4 also the second level variables are added to the model. The first thing to notice is that the variables of interest and first level variables don't change in sign or significance level. Therefore there is no need to discuss this further in this section. What is interesting is that after adding the second level control variables the unexplained variance at the second level drops to 0.152. The control variables provide a extra (0.367-0.152)/0.367*100=21.5% in explained variance at the municipality level. Taking a look at the control variables which are added only one variable is not significant. This variable is the percentage of jobs without PT accessibility in a municipality. The influence of P&R facilities, congestion and density are all positive on PT use and significant at the 0.01% level. Interpretation of the congestion variable gives the following: an increase in the congestion figures with 1 in a municipality increases the predicted probability of PT use on average with 0.293 percentage points for an individual with mean characteristics, ceteris paribus.

With the help of model 4 an answer can be given to sub-question 1 and 2. The first sub-question was: *"To what extent do parking tariffs in municipalities of the working place affect the use of Public Transport in commuting?"* Taking a look at model 4 parking tariffs have a positive effect on the use of PT in commuting and it is significant at the 0.01%

level. An increase of parking tariffs with 1 Euro in an municipality increases the predicted probability of PT use with 2.946 percentage points for an individual with mean characteristics, ceteris paribus. This means that sub-question 1 can be accepted. The second sub-question is: "*To what extent do the quality of the PT in municipalities of the working place affect the use of Public Transport in commuting?*" Taking a look at model 4 PT-quality has a positive effect on the use of PT in commuting and it is significant at the 0.01% level. An increase of the PT-quality with 1 frequency per week in a municipality increases the predicted probability of PT use on average with 0.001 percentage points for an individual with mean characteristics, ceteris paribus. This means that also sub-question 2 can be accepted.

For the third sub-question model 5 is build with an interaction variable. The interaction is between PT-quality and Parking Tariffs. When comparing model 5 with model 4 no interesting differences can be found. The decrease in the log-likelihood is small and a likelihood-ratio test with a p-value of 0.4768 shows that model 5 is not significant better than model 4(Appendix). Furthermore all variables still have the same sign and significance level. The interaction variable has a negative value of 0.0000211. The effect of PT-quality on PT use is depending on parking tariffs. So if parking tariffs are 1 euro in a municipality the predicted probability of PT use is 0.00001-0.00000*1=0.00001 for an individual with mean characteristics, ceteris paribus. The effect of PT-quality on PT use is decreasing by the influence of parking tariffs on PT quality. But the interaction effect is not significant, what means that there is not enough evidence that the effect of PT-quality is depending on parking tariffs. The third sub-question reads as follows: "*Is the effect of quality of the PT on the use of PT in municipalities of the working place strengthened by the presence of parking tariffs?*" With the results of model 5 this third sub-question has to be rejected.

Conclusion

Conclusion

In the Netherlands the government is just like other governments trying to reduce traffic on the road. One way to achieve this is to switch people from the car to PT. According to Kennisinstituut voor Mobiliteitsbeleid(2015) this is only possible with high parking tariffs/parking problems and a high qualitative PT on the route. This research combines data of commuters in the Netherlands together with data from municipalities to find out if these factors are really important for switching people from the car to the PT. Therefore the research question was as follows: '*How do parking tariffs and quality of the PT of municipalities of the working place affect the use of Public Transport in commuting?*' With the help of a mixed-effect logistic regression with two levels five models are made.

The first level is at an individual level and the second level is on municipality level. Besides variables for parking tariffs and quality of the PT some control variables at the first and second level are included in the models. After analyzing the results some conclusions could be made. First of all the effects of parking tariffs and quality of the PT have been measured separately. It comes out that these variables both have a significant positive effect on PT use. With this information policy makers must be recommended to increase parking tariffs or increase the quality of the PT if they want to increase PT use. However the report of Kennisinstituut voor Mobiliteitsbeleid(2015) claimed that both higher parking tariffs as higher quality of the PT are needed to switch people from the car to PT. But in this research there is no significant interaction effect found between those variables. So higher parking tariffs as a higher quality of the PT have an positive effect on the use of PT, but they don't strengthen each other recording to this research. Therefore the conclusion of this research is that it is not necessary to increase both of them at the same time. For policy makers a focus on one of them should be enough to gain an increase in PT use.

Discussion

The mixed-effects logistic regression used in the models with this kind of variables and the number of observations gives that this research looks more completed than most other research in this field. However there are some points that could be improved. The focus of the research is now on municipalities of the working place. But commuters also have a living place where for example the quality of the PT is also important(Pinjari,2011). For further research also the effect of the living place could be measured. One step further is too measure also the effects of the environment during the trip from the living place to the working place. Furthermore the variables of interest could be specified more precisely. Now the quality of PT is measured by PT frequencies. But the quality of the PT includes more than that, for example the reliability, comfort levels etc. The parking tariffs are an average of the known public parking garages of each municipality. The tariffs could differ in the municipality itself too. The city centre could be very expensive for parking, while the tariffs at business districts could be much lower. For further research the two variables could be more comprehensive. Also mobility management measures are missing in this research. This could be an important factor, especially for commuters(Vanoutrive et all, 2010). Companies could have their own measures to reduce car use of their employees.

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Appendix

Likelihood-ratio test

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Likelihood-ratio test                                 LR chi2(1)  =      0.51
(Assumption: m1 nested in m2)                         Prob > chi2 =    0.4768
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