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master in de verkeerskunde: mobiliteitsmanagement
(Interfacultaire opleiding)

Masterproef

Free public transport: a socio-cognitive analysis

Promotor :
Prof.dr.ir Tom BELLEMANS

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Masterproef voorgedragen tot het bekomen van de graad van master in de verkeerskunde , afstudeerrichting mobiliteitsmanagement

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Free public transport: a socio-cognitive analysis

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ABSTRACT

In this study, the modal shift potential of introducing a free alternative (free public transportation) and changing the relative prices of transportation is examined. The influence of a forced cognitive analysis (imposed on half of the respondents) on the zero-price effect is also analyzed. Second research objective was to find explanatory factors in explaining fare evasion. The data used for the analysis stem from a stated preference survey with a sample of around 670 respondents which was conducted in Flanders, Belgium. The data is analyzed by using a mixed logit model for the modal choice models and a logistic regression for the fare evasion model. The modeling results yield findings that confirm the existence of a zero-price effect in transport, which is in line with literature. This zero-price effect is enhanced by the forced cognitive analysis in certain motives. Results also demonstrate the importance of the current mode choice in hypothetical mode choices and the importance of car availability. The influence of changing relative prices on the modal shift is not found significant. Hence, an increase in public transport use can be facilitated by the introduction of free public transport, certainly when people evaluate the different alternatives in a more cognitive manner. Results also indicate that gender, age and fines for evading fares are the most important explanatory factors for fare evasion. These findings can be used by policy makers to make public transport more successful and to reduce the amount of fare evaders.

1. INTRODUCTION

Transportation has become extremely important in modern life. Everybody is, in some way, either directly or indirectly affected by transport. Its availability and accessibility dictates how, where and when we travel. Transport modal choice impacts many aspects of our lives including our work, leisure and health *(1)*. The dependence on the car in everyday travel has increased enormously in the last decades. This has serious and growing consequences for the environment (e.g. greenhouse emissions) and health (e.g. casualties) damaged by road traffic. At the same time, these consequences are very expensive for business (e.g. time lost due to congestion), environment and society *(2)*. Rising concerns over these increasingly intolerable externalities have generated particular interest in how transport-planning policies might moderate the pressures resulting from growth in personal mobility and support the principles of sustainable development *(3)*. The problems of car use might be reduced in different ways. First, the negative impact per car and per kilometer driven may be reduced via technological innovations that, e.g., increase the energy efficiency of cars, reduce emissions per car kilometer. This policy tends to be overtaken by the continuing growth of motorized traffic in the world. A second policy that formerly was very popular, is the creation of new road infrastructure. This reduces the congestion problems but the environmental and health problems are likely to increase *(4)*. A third policy is stimulating people to drive at other times or places. This strategy also reduces the congestion problems but increases the environmental and health problems. The fourth policy aims at reducing the level of car use by stimulating people to use other modes of transport, to combine trips, or to travel less. The fifth intervention aims at making people drive more safely or more environmentally friendly *(4)*.

This paper aims to identify factors that influence an individual's mode choice by anticipating on people's motivation to use other modes of transport. The need for using other modes of transport is enormous because public transport (especially electric trains, trams and buses) seems a promising way to deliver passenger transportation. This is because it performs perhaps five or ten times better than cars in terms of energy per passenger-km *(5)*. Still the car is more attractive than public transport because of its convenience, independence, flexibility, comfort, speed, reliability and because driving is perceived to be more pleasurable *(4)*. Another reason why it is so difficult to persuade people to use other travel modes instead of the car is habitual character of the modal choices. Habits are formed when a behavior is repeated frequently in a stable context and leads to rewarding outcomes *(6)*. But there is potential to persuade people to switch to public transport when a set of circumstances are met. These include travel cost savings, frequency of service, time savings, accessibility to jobs, a variety of payment types, and the opportunity to do other things while traveling *(7)*. Other studies indicate that travel choice is governed by number of factors, most notably travel time, availability of a car and of discounted long term tickets and fares *(8)*. When one of these factors can be so powerful that it disrupts the context where habitual behavior is performed, progress can be made in influencing the modal split. The saving of travel cost, or travel fares, is a factor in the modal choice worth looking into. This is because different studies *(1, 4)* show that the transportation price is one of the few evaluation factors where public transport can beat car transport. Improving one of the other evaluation factors is also worth investigating, but it will be difficult bringing them at a higher level than car transportation. Fares are a direct and flexible instrument to influence passenger behavior and cost recovery of a public transport system *(8)*. So to motivate people to use public transport, fares should be lowered at a level where the traveler is determined to choose for public transport. This can be public transport at a reduced price or it can be free public transport. Nevertheless, it should be noted that free public transport does not exist and it will never exist in the future. Free public transport means that the user of the public transport system, does not have to pay for his journey. Instead there is a third party who pays the price of the public transport *(9)*.

This paper examines the effect of transport at a reduced and at a zero-price. To investigate this effect, the respondent his actual mode choice is compared with the mode choice knowing the genuine prices of transport, with the mode choice of the respondent when faced with reduced transport prices and with the mode choice of the respondent when the transport prices are further reduced so that public transport becomes free for the transport user. Fares, next to other determinants, could also play a role in fare dodging, which also will be examined in this paper.

2. LITERATURE REVIEW

2.1. Zero-Price effect

In this section, an explanation for the zero-price effect and some factors influencing the zero-price effect are sought. The word "free" can mean several things, but it always boils down to: moving the costs of a product or service from person to person, between the past and the future, in non-monetary markets and back out *(10)*. A free product used to be nothing more than an attention-grabbing marketing trick. But today, businesses can often profit more by giving products away, than by charging for them. Smith *(11)* indicated that when there is a voluntary exchange between two parties, both parties will have benefit. Free is becoming a strategy that is essential for any company to survive. The success of a free product lies in the zero-price effect. The zero-price effect is an overreaction to a free product when people are faced with a choice between two products, one of which is free. This overreaction is in such extend as if the zero price meant not only a low cost of buying the product, but also its increased valuation *(12)*. People see zero as more than just another price. The power of "free" also suggests that once a free item is priced above zero, demand for that item could plummet significantly, more than what conventional economics would predict *(13)*. An explanation for this zero-price effect can be found in the mental transaction costs *(14)*. The mental transaction cost is a process that appears with every purchase of a priced product. The customer will ask himself whether this product is worth its price. In case of a free product, the lacking of this mental transaction cost makes it easier to convince people. Disadvantage of lacking a mental transaction cost is that there is no commitment, and that people attach more value to products where they have paid for.

In the prospect theory *(15)*, an explanation for the individual consumer choice behavior is examined. The prospect theory assumes that the choice process consists of two stages. In the preparation stage the individual sets a reference point for a certain choice. In the evaluation stage, the outcome will be compared to the reference point. The zero-price effect makes the reference point for relative thinking disappear *(16)*. This disappearance of the reference point creates a positive feeling within the consumer which is used to make the decision for buying a product. It has been suggested that this positive feeling is derived from the fact that the purchase implies only benefits, no costs. When this feeling is eliminated, the zero-price effect will disappear.

The zero-price effect was examined for several products, like chocolates in *(12, 17)*, telecommunication in *(18)* and stereo-systems *(17)*. These studies generally confirm the zero-price effect. Especially when it comes to simple decisions, the zero-price effect is found to be significant. In more complex decisions about more expensive products, there wasn't found a unilateral conclusion about the significance of the zero-price effect. Of all the possible explanations, the psychological mechanism affect was found to be the only significant motive for the zero-price effect. This mechanism makes sure that options with no downside (no cost) invoke a more positive affective response; to the extent that consumers use this affective reaction as a decision-making cue, where they opt for the free option *(19, 20)*. Mapping difficulty and the social norm were the other psychological mechanisms that were examined but weren't found to influence the zero-price effect significantly *(12)*. Mapping difficulty is the difficulty consumers have with mapping the utility they expect to receive from hedonic consumption into monetary terms *(21)*. Social norm, which is the norm that consumers use when deciding over a free product, is different from the market norm.

About the place of the affect-mechanism in the decision making process, there is much controversy. Peine et al *(22)* proposed the Appraisal Theory of Lazarus. In this theory, cognition comes first in the decision making process before the affect mechanism. In the study of Shampanier et al *(12)* this theory is confirmed. This means that the positive feelings about the free product lead to an increased demand of the free product. This theory is in contrast with the theory of Zajonc *(22, 23)*. In this theory is stated that affect can be generated without the participation of cognition, which proves that affect shouldn't be preceded by cognition. This theory is supported by the results of several studies *(17, 18)*. In practice both orders appear. The strength of influence of the affective and cognitive evaluation depends on the situation in which they occur, the focus during the decision, processing resources available in the decision making process and the involvement of the decision maker *(17)*.

2.2. Zero-price effect in public transport

Public transport fares are confronted with a number of contradictory needs and requirements. On the one hand, fares should be increased due to e.g. budgetary requirements and dividends to owners. On the other hand, there

are strong pressures to keep fares low and subsidies high because people value public transport strongly but they consider it as too expensive or infrequent to effectively replace private transport *(25)*. Objectives such as social inclusion, fairness, internalization of external benefits and corrections for underpriced private transport pull in the direction of lower fares *(26)*. Fares can also have an impact on traffic safety. Although reductions in fares for public transport provide smaller direct safety benefits, they can have much larger impacts if they help create more transit-oriented communities where residents tend to own fewer cars and drive less than they would otherwise *(27)*. Weis et al *(28)* computed price elasticity's suggesting that respondents are more sensitive to public transport increases than to rising fuel prices. So it may be expected that an increase of the prices in public transport will result in a decrease in the demand for public transport *(29)*. Thus, fares are an important variable in both the increase of usage as the improvement of cost-benefit ratio. Several studies have been conducted about how certain determinants, such as price, affect the modal choice. Thorgrsen *(30)* illustrated that motivation, past behavior and habits, opportunities or constraints regarding the use of public transport and car ownership are determining the mode choice. A modification in fares can influence some of these determinants. A decrease in fares until zero could influence motivation. This is because the zero-price effect will elicit positive feelings towards public transport *(12)*. This will influence the attitude, which powers the behavioral intention to use public transport *(31)*. Next to the motivation, free public transport could increase the opportunities regarding the use of public transport. The study of Thorgrsen *(30)* indicated the importance of habits as a determinant of mode choice. Habits are a form of automaticity in responding that develops as people repeat actions in stable circumstances *(32, 33)*. To change these habits interventions can be applied upstream and downstream of the behavior *(32)*. Downstream interventions aim at the avoiding of existing negative outcomes, while upstream interventions intent to avoid the outcome in the first place. Free public transport is an example of a downstream intervention, but the results of the study of Verplanken and Wood *(32)* showed that an economic incentive was only effective with weakly or not habitual behavior, while mode choice typically is strongly habitual. These results contradict the results of the study of Fujii and Kitamura *(34)*, where the effect of a temporary change in the level of service on habitual drivers has been measured. The results showed that a structural change in the level of service (e.g. free bus ticket, temporary road capacity reduction) led to an increased usage of the public transport which was sustained after the period of temporary, structural change. Also the attitude towards public transport use was higher than before the structural change, and the habitual behavior of car usage was reduced. De Witte et al *(35)* found that there was a certain margin of growth in the usage of public transport when it would become free, but it should be combined with investments in quality of public transportation (e.g. frequency, capacity, connections). In a study of Boyd et al *(36)* the modal shift on the campus of the University of California at Los Angeles was examined after making bus transport free of charge. Transit ridership increased by more than 50% while more than 1000 fewer automobile trips were taken to the campus each day. Steenbergen et al *(37)* investigated the effects of free public transport for students in Brussels. They found that public transport ridership increased by making it free, although they couldn't draw significant conclusions due to the lack of a control group. Steenbergen et al *(37)* also conducted a cost-benefit analysis. They illustrated that the introduction of free public transport can increase the social surplus as long as no more than 86% of the space made available on the road is filled up by new car users. Verheyen *(38)* investigated the effect of free public transport on the modal split, but he made a distinction according to trip motives; commuting, shopping and recreation. The results indicated that the zero-price effect only was significantly influential in the shopping motive.

2.3.Fare evasion

Subsidies for public transport, often calculated as the difference between operating costs and passenger fare revenues, are a subject of large controversy. In Europe, fares cover on average 50% of the operating costs *(39)*. There are many reasons for this ratio being as low as it is. One of the reasons is fare evasion, although it also could be a consequence of transport fares as indicated above. Fare evasion occurs when passengers gain access from public transport by interacting with fare controls in manners that are inconsistent with tariff *(40)*. Bijleveld *(41)* indicated that fare evasion pulls down the incomes of the public transportation company. Consequently passengers should be inspected, which is a large cost. Inspection implicate delays, which decreases reliability. And when fare evaders are prosecuted, additional costs fall on the police and the criminal justice system *(42)*. Fare evasion also evokes anti-social and criminal behavior related with attempts to avoid enforcement. According to Dauby and Kovacs *(43)* the attitude to evade fares is distributed in three groups. Five percent of the population is persistent dishonest, ten percent is persistent honest and the other eighty five are opportunistic

fare evaders, which means that they will try to evade fares when the perceived chance of being caught is smaller than the perceived chance of getting away with it. The largest causes for fare evasion are: forgetting the payment and low incomes *(44)*. The fact that low income is found to be a major cause of fare evasion, demonstrates the possible importance of fares in fare evasion.

3. DATA

A stated preference survey was conducted to examine whether a price effect and/or a zero-price effect occurs among respondents in Flanders (the northern part of Belgium). The total population in 2010 amounted to 6.2 million inhabitants. An average Flemish respondent makes 2.8 trips a day. 68% of these trips are made by car, followed by 12.28% by foot, 11.91% by bike, 2.71% by bus and 1.78% by train *(45)*.

Stated preference methods are universally accepted in travel behavior research and the practice of identifying behavioral responses to choice situations which are not revealed in the market *(46)*. The principal drawback is that individuals' stated preferences may not correspond closely to their actual preferences *(47)*. Despite this drawback, Wardman *(48)* found evidence that individual's stated preferences among hypothetical travel scenarios are a reasonably accurate guide to true underlying preferences. The SP-survey was conducted on a person based level from mid-November 2012 to late January 2013 and was filled out by random individuals which are assumed to make their own transport decisions (over 17 years of age). The survey was distributed over the internet allowing flexible question ordering to be included in the survey. This flexible question ordering counters question order effects. Typically, question order effects result in differences in means and correlations for specific and general questions and result from changes in the placement of specific (general) questions relative to general (specific) questions in the survey *(49)*. In total, the survey collected valuable information of 670 respondents.

The stated preference questionnaire consisted of four parts. The first part of the survey consisted of some socio-economic variables (e.g. gender, age, , household situation, income, etc.). In addition to the socio-economic variables, information about the respondent's transport situation was obtained in the second part (e.g. car availability, current use of modes, etc.). In part three, the respondents had to indicate their modal preferences among a set of three alternatives with certain prices or tariffs. Each respondent was confronted with nine modal choices (3 price scenarios x 3 motives). In price scenario A, the respondents were confronted with the actual transport prices. Actual prices for the car were determined using a study of De Ceuster *(50)* who estimated a complete cost per kilometer (e.g. fuel, net purchase vehicle, maintenance, insurance, fuel tax, etc.). For the bike a fixed cost was calculated based on the net purchase cost and the maintenance cost. The actual cost for the bus was estimated on the subscription fee charged by the Flemish transport company. Because the subscription fee as the costs for the bike are fixed costs, the assumption was made that this mode was used on a (work)daily base. In price scenario B the tariff of the public transport was halved. The tariffs of the other modes were decreased with the same amount. In price scenario C, the prices and tariffs were again decreased with the same amount, making the public transport option free. This allows measuring the reaction to a price reduction towards a positive price as well as the reaction to the same price reduction towards a zero price. Each of these three price scenarios consist of three motives, a work/school motive, a shopping motive and a recreational motive. For the work/school motive, a distance-related cost was calculated for the car option based on the distance to work or school the participants indicated. In the shopping motive, the cost for the car was based on a distance of approximately 5 kilometers to a shop. In the recreational motive, the cost for the car was based on a trip length of approximately 15 kilometers to the nearest cinema. For the bike and public transport the cost were fixed per trip and constant over the three motives. The fourth part of the survey consists of questions about public transport in general and fare evasion. First the respondents were asked about their perceptions of the tariffs of public transport, fare evasion checks, fines on fare evasion. Subsequently they were asked about their own behavior of fare evasion and their reasons for doing this.

The table below give an overview of the data types and the corresponding coding of the variables that were collected in the survey. Due to the large number of variables, only the variables that are included in the final models are presented here. The descriptive statistics are displayed in the attached annex A**.**

TABLE 1 Overview of the variables collected in the survey

Variable	Data type	Remarks (Coding)
Modal Choice Model		
Socio-economic variables		
Man_D2	Categorical	Bike dummy: 1 if man, 0 if woman
Age_D2	Numeric	Bike dummy: Age of the respondent
Alone_D3	Categorical	PT dummy: 1 if respondent lives alone, 0 otherwise
Inc_D2	Categorical	Bike dummy: 1 if income of the respondent between €0 and €1500, 0 otherwise
Inc_D3	Categorical	PT dummy: 1 if income of the respondent between €0 and €1500, 0 otherwise
IncNS_D2	Categorical	Bike dummy: 1 if income not specified, 0 otherwise
IncNS_D3	Categorical	PT dummy: 1 if income not specified, 0 otherwise
Urb_D2	Categorical	Bike dummy: 1 if respondent lives in urban area, 0 otherwise
Transport-related variables		
DistHomeWS_D2	Numeric	Bike dummy: Distance between home and work
DistHomeWS_D3	Numeric	PT dummy: Distance between home and work
CarAvail_D2	Categorical	Bike dummy: 1 if car is usually or always available, 0 otherwise
CarAvail_D3	Categorical	PT dummy: 1 if car is usually or always available, 0 otherwise
CUWS_D1	Categorical	Car dummy: 1 if respondent uses car for work/school trips currently, 0 otherwise
CUWS_D2	Categorical	Bike dummy: 1 if respondent uses bike for work/school trips currently, 0 otherwise
CUWS_D3	Categorical	PT dummy: 1 if respondent uses public transport for work/school trips currently, 0 otherwise
CUShop_D1	Categorical	Car dummy: 1 if respondent uses car for shop trips currently, 0 otherwise
CUShop_D2	Categorical	Bike dummy: 1 if respondent uses bike for shop trips currently, 0 otherwise
CUShop_D3	Categorical	PT dummy: 1 if respondent uses shop for work/school trips currently, 0 otherwise
CURecr_D1	Categorical	Car dummy: 1 if respondent uses car for recreational trips currently, 0 otherwise
CURecr_D2	Categorical	Bike dummy: 1 if respondent uses bike for recreational trips currently, 0 otherwise
CURecr_D3	Categorical	PT dummy: 1 if respondent uses shop for recreational trips currently, 0 otherwise
ExpPT_D3	Categorical	PT dummy: 1 if respondent has experience with free public transport, 0 otherwise
Modal choice variables		
Bike_D2	Categorical	Bike dummy: 1 if mode is bike, 0 otherwise
PT_D3	Categorical	PT dummy: 1 if mode is public transport, 0 otherwise
RelCostWS	Numeric	Prices and tariffs for the work/school motive relative to the car
RelCostShop	Numeric	Prices and tariffs for the shopping motive relative to the car
RelCostRecr	Numeric	Prices and tariffs for the recreational motive relative to the car
Free	Categorical	Dummy: 1 if mode is free, 0 otherwise
Fare Evasion Model		
Gender	Categorical	Dummy: 1 if gender is man, 0 if gender is woman
Age	Categorical	Dummy: 1 if years passes since birth is lower or equal than 25, 0 otherwise
PercPrice	Categorical	Dummy: 1 if prices of public transport are perceived to be too high or high, 0 otherwise
PercChecks	Categorical	Dummy: 1 if number of checks against fare evasion are perceived to be too high or high, 0 otherwise
PercBusFine	Categorical	Dummy: 1 if fine for evading fares on a train is perceived to be high, 0 otherwise
PercTrainFine	Categorical	Dummy: 1 if fine for evading fares on a bus is perceived to be high, 0 otherwise

Besides completing the survey, 50% of the respondents were subjected to a cognitive analysis. This cognitive analysis was assigned on a random basis, to test whether respondents use an increased affect by the free option as a cue for their decisions, which in turn causes the zero-price effect. By this cognitive analysis, the participants were forced to engage in a cognitive and deliberate evaluation of the alternatives before they choose, and thereby make non-affective, more cognitive evaluations available and accessible. In this cognitive analysis, the participants were asked to evaluate certain prices and certain transportation modes. We assume that in these conditions, participants are more likely to base their evaluations on cognitively available inputs and therefore place a lower weight on the affective evaluations. When this increased affect causes the zero-price affect, reliance on cognitive inputs should reduce the zero-price effect. The cognitive analysis is displayed in the attached annex B.

4. METHODOLOGY

The main research objective of this paper is to assess the impact of specific prices on modal choices and examining contributing factors to fare evasion. In this section, the methodology for both research objectives is stated.

4.1.Zero-price model

In the first part of the study, the focus is to assess whether the zero-price effect and price effect play a role in the transport decision process and what other factors affect this decision. In the previous section, it was expounded that each respondent had to indicate the preferred mode for a number of hypothetical situations. Therefore, a modeling approach is needed which takes into account correlated responses for the choice among three or more categories. The multinomial discrete choice procedure analyzes models where the choice set consists of multiple alternatives. This procedure supports conditional logit, mixed logit, heteroscedastic extreme value, nested logit, and multinomial probit models. The MDC procedure uses the maximum likelihood (ML) or simulated maximum likelihood method for model estimation. In this case, a mixed logit model is developed to estimate these relationships. As indicated by Hoffman and Duncan *(51)*, the mixed logit model is a combination of a multinomial logit and a conditional logit model. The multinomial logit focuses on the individual as the unit of analysis and uses the individual's characteristics as explanatory variables. The conditional logit focuses on the set of alternatives for each individual and the explanatory variables are characteristics of those alternatives. A mixed logit model includes both characteristics of the alternatives and the individual. The corresponding choice probability can be written as:

$$P_{ij} = \sum \exp (X_i\beta_j + Z_{ij}\beta) / \exp (X_i\beta_k + Z_{ik}\alpha)$$

Where an individual has to choose among a set of J alternatives, and X_i stands for the characteristics of individual i and Z_{ij} for the characteristics of the jth alternative for individual i, with the corresponding parameter vectors denoted by β and α, respectively.

Three models were estimated in order to assess whether the zero-price effect and the price effect play a significant role in the modal decisions of the respondents: a model for the work/school motive (model 1), a model for the shopping motive (model 2) and a model for the recreational motive (model 3). Next to examining the effects of zero-price and the prices, other personal and transport-related variables are included in the model to explain the modal choices further. Forward selection was used to find the most significant variables in the model. Forward selection adds variables to the model one at a time. Every step, each variable not yet included in the model is tested for inclusion. The most significant variable is then added to the model, as long as its P-value remains below the significance level of 0.05.

4.2.Fare evasion model

In the second part of the study, the focus is shifted to a model examining the factors that determine whether or not people evade fares. In the survey the respondents had to indicate whether they have evaded fares in the past or not. This variable is a binary outcome. This study used logistic regression to build the relationship between

fare evasion and its explanatory variables. Logistic regression is a statistical method used to analyze data in which there are one or more independent variables that determine a binary outcome *(52)*. The model equation is given by:

$$\log (\pi_i/1-\pi_i) = \theta + X_i\beta$$

Where $(\pi_i/1-\pi_i)$ denotes the odds;
θ the intercept;
Xi is a vector of variables observed which affect whether to evade fares or not;
β is a vector of unknown regression coefficients, which can be estimated by standard maximum likelihood methods.

The above equation can be rewritten to the likelihood function of a binary logit model:

$$\Pi_i = \exp (\theta+X_i\beta) / 1 + \exp(\theta+X_i\beta)$$

The first equation shows that the estimated parameters have to be interpreted as the change in the predicted logged odds for a one unit change in the corresponding explanatory variable *(53)*. An odds can be defined as the probability of an event occurring divided by the probability of no event occurring. In this paper, the probability of an event equals the likelihood to evade fares. The most common way to interpret the parameter estimates, is the interpretation using the odds ratios (OR). The odds ratio can be calculated by taking the exponent of the parameter estimate ($e\beta$). If the odds ratio is greater than 1, than this represents an increase in the odds of the event explained (to evade fares). If the odds ratio is smaller than 1, than this represents a decrease in the odds of the event explained. This increase (decrease) implies that for every unit raise in the corresponding explanatory variable, the probability increases significantly. Also the parameters can be interpreted by the sign of the parameter estimates. A positive sign implies an increase in the likelihood of an event for every increase in the corresponding explanatory variable and vice versa. When building the model, also here forward selection was used to find the most relevant variables in the model.

5. RESULTS

5.1. Overall Results

The overall significance tests for the final models are displayed in TABLE and TABLE . From TABLE it can be concluded that the relative cost does not significantly affect the modal choice of the respondents. This is true for all trip motives considered in the study. On the other hand, the presence of a free alternative does affect the modal choice significantly for work/school and shopping trips. In addition this effect is only borderline non-significant for the recreational motive. Age does only affect the choice for the bike in recreational trips, gender does affect the choice for the bike in both shopping and recreational trips. The living situation does affect the choice for public transport significantly in the shopping and recreational motive. The distance to work or school has an impact on the choice for the bike and public transport, this is naturally only the case in the work/school motive. Income affects the choice for the bike significantly in the three motives, while it only affects the choice for public transport significantly in the recreational motive. Whether a respondent lives in an urban environment or not, only affects the choice for the bike significantly in the recreational motive. The car availability does affect the choice for the bike significantly in the work/school and recreational motive, and it affects the choice for public transport significantly in the three motives. The current use of transportation modes for the three motives has a significant impact on the three modes in the survey for the three motives. And finally, an experience with free public transport does affect the choice for public transport significantly in the work/school motive and the recreational motive.

From TABLE can be deduced that gender significantly affects whether to evade fares or not. Also age has an significant impact on the tendency of respondents to evade fares. Next to that, some perceptions have a significant impact on the evasion of fares. The perception of tariffs of public transport and the perception of the amount of checks on fare evasion significantly affect fare dodging behavior. Also the perception of the magnitude of fines for fare evasion affect the behavior of fare evasion significantly, this both in case of bus as train transport.

TABLE 2 Results of the Overall Significance of the Modal Choice Model

	Work/school motive				Shopping motive				Recreational motive			
	DF	t Value	P-value	Sign.	DF	t Value	P-value	Sign.	DF	t Value	P-value	Sign.
Bike_D2	1	3,17	0,0015	**	1	-1,58	0,113	NS	1	-0,72	0,4709	NS
PT_D3	1	-1,35	0,1764	NS	1	-1,99	0,0466	NS	1	0,37	0,7127	NS
RelCostWS	1	-1,08	0,2787	NS								
RelCostShop					1	0,18	0,857	NS				
RelCostRecr									1	0,57	0,5695	NS
Free	1	2,4	0,0162	**	1	4,33	<0,0001	***	1	1,88	0,0599	NS
Age_D2									1	1,98	0,0481	*
Man_D2					1	3,38	0,0007	***	1	3,22	0,0013	**
Alone_D3					1	4,32	<0,0001	***	1	2,73	0,0063	**
DistHomeWS_D2	1	-5,87	<,0001	***								
DistHomeWS_D3	1	3,14	0,0017	**								
;Inc_D2	1	-6,6	<,0001	***	1	4,13	<0,0001	***	1	2,55	0,0108	*
Inc_D3									1	2,94	0,0033	**
IncNS_D2	1	-3,52	0,0004	***								
IncNS_D3	1	3,26	0,0011	**								
Urb_D2									1	-1,99	0,0468	*
CarAvail_D2	1	-2,79	0,0053	**					1	-3,71	0,0002	***
CarAvail_D3	1	-3,3	0,001	***	1	-7,07	<0,0001	***	1	-5,11	<0,0001	***
CUWS_D1	1	8,72	<,0001	***								
CUWS_D2	1	13,46	<,0001	***								
CUWS_D3	1	6,22	<,0001	***								
CUShop_D1					1	7,71	<0,0001	***				
CUShop_D2					1	7,21	<0,0001	***				
CUShop_D3					1	2,88	0,004	**				
CURecr_D1									1	5,49	<0,0001	***
CURecr_D2									1	5,23	<0,0001	***
CURecr_D3									1	2,34	0,0192	*
ExpPT_D3	1	3,07	0,0022	**					1	2,37	0,0177	*

** P-value <.05, ** P-value < .01, *** P-value < 0.001, NS = not significant*

TABLE 3 Results of the Overall Significance Type III-Test of the Fare Evasion Model

Parameter	DF	Chi²	P-value	Sign.
Gender	1	13,13	0,0003	***
Age	1	24,76	<0,0001	***
PercPrice	1	4,315	0,0378	*
PercChecks	1	7,507	0,0061	**
PercBusFine	1	3,944	0,047	*
PercTrainFine	1	7,981	0,0047	**

** P-value <.05, ** P-value < .01, *** P-value < 0.001, NS = not significant*

5.2.Parameter estimates

The parameter estimates for the binary mode choice models are shown in Table 4. The most used way to interpret the parameter is by the sign and the magnitude of the parameters.

5.2.1. Work/school model

In the work/school model, the parameter that represents the zero-price effect has a positive sign. This implies an increased modal share for public transport when it is available for free. The distance between the home location and the work or school location has a negative sign for the bike and a positive sign for public transport. Thus, an increase in distance between the home location and the work or school location decreases the modal share of the bike and increases the modal share of public transport. The income parameter of the bike has a negative sign. This implies an increase of income significantly lowers the likelihood to use the bike when travelling to work or school. The car availability parameters of the bike and public transport show a negative sign. This indicates a lower probability of choosing the bike and public transport when the car is usually or always available. The current use parameters show all three positive signs which is quite logical. When a respondent uses a specific mode in daily life, the likelihood for choosing this specific mode increases in the hypothetical situations. This means that the respondents' choice in hypothetical situations depends partly on the current modal choice in daily life for a specific motive.

5.2.2. Shopping model

In the shopping model, the parameter representing the zero-price effect is positive, which suggests an increased probability of choosing public transport when it is made available for free. The magnitude of the parameter shows that the zero-price effect is more powerful in the shopping motive than in the work/school motive. There is also a difference in the zero-price effect for people who were subjected to a cognitive analysis and people who were not. The respondents were divided into two groups, where one group who was subjected to a cognitive analysis and one group who was not. The parameter estimate of the zero-price effect for the group which was subjected to the cognitive analyses amounts to 1.0572, whereas the parameter estimate of the zero-price effect for the group which was not subjected to the cognitive analyses amounts to 0.6376 (See annex C and D). So we can conclude that the zero-price effect is greater when people are forced to engage in a cognitive and deliberate evaluation of the alternatives before they choose, and thereby make a less affective and more cognitive decision. The gender parameter has a positive sign for the bike mode. This means that men have a significant higher probability of choosing the bike in the shopping motive than women. Also the living situation parameter has a positive sign for the public transport option. This indicates a higher probability of choosing public transport in the shopping motive when people live alone compared to people who don't live alone. The income parameter of the bike shows, in contrast to the work/school motive, a positive sign. This implies that the likelihood of choosing the bike in the shopping motive is higher for people with a low income. The car availability parameter of the bike shows a negative sign. This indicates a lower probability of choosing the bike when the car is usually or always available. The current use parameters show all three positive signs which is logical. When a respondent uses a specific mode in daily life for shopping trips, the probability of choosing this specific mode increases. This indicates that the likelihood of choosing a specific mode is enhanced when this mode is used in daily life for these motives. When we compare these parameters with the daily use parameters of the work/school motive we see that these parameters show lower values. This means that the modal choices depend to a lesser extent on the current use of modes in the shopping motive compared to the work/school motive.

5.2.3. Recreational model

The parameter representing the zero-price effect in the recreational model has a positive sign, but the parameter is not significant because the p-value exceeds the significance level of 0.05. The significance level was for this parameter only exceeded by two hundredth. So the zero-price effect in the recreational motive can be considered significant at the significance level of 0.10. The age parameter concerning the bike has a positive sign, which implies that the probability of choosing the bike as mode of transport for recreational trips increases as age increases. The gender parameter has a positive sign for the bike mode. This means that men have a significant higher probability of choosing the bike in the recreational motive than women. The gender parameter in the recreational model is higher than in the shopping model, which implies that the difference between men and women is more distinct in the recreational model than in the shopping model. The living situation parameter

shows, like in the shopping model, a positive sign for public transport. This means that people who are living alone, are more inclined to use public transport for recreational trips than people who are not living alone. This parameter is smaller than in the shopping motive, so the effect of living situation is less distinct than in the shopping model. The income parameter for the bike shows a positive sign. This is in contrast with the work/school scenario but it is consistent with the shopping scenario. We can conclude that people with lower incomes are more inclined to use bike for recreational trips. And income plays a greater role in the recreational motive than the shopping motive. The income parameter for public transport also shows a positive sign, which implies that the likelihood of choosing public transport in the recreational motive is higher for people with a low income. The parameter that includes whether the respondent lives in a urban environment or not, shows a negative sign for the bike. This implies that people are less inclined to use the bike for recreational trips when they live in urban environments. The car availability parameters of the bike and public transport show a negative sign. This means that there is a lower probability of choosing the bike and public transport when the car is usually or always available. The car availability has the most influence on bike use in the shopping trips, following by the recreational trips and has the least influence on the work/school trips. This while the car availability has more influence on the public transport use in work/school trips than in the recreational trips. The current use parameters of the car, bike and public transport modes show positive signs. This indicates that the likelihood of choosing a specific mode is enhanced when this mode is used in daily life for these motives. The parameter which represents the experience with free public transport shows a positive sign. This indicates that the probability of choosing public transport is enhanced after experiencing free public transport.

TABLE 4 Parameter Estimates for the Modal Choice model

Parameter	Work/school model		Shopping model		Recreational model	
	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Bike_D2	1,8369	0,5792	-0,9648	0,6087	-1,8835	2,6124
PT_D3	-0,8761	0,6481	-1,2309	0,6186	0,9452	2,5665
RelCostWS	-0,8518	0,7864				
RelCostShop			0,1259	0,6988		
RelCostRecr					1,5377	2,7032
Free	0,3541	0,1473	0,8413	0,1941	0,3172	0,1686
Age_D2					0,0176	0,00888
Man_D2			0,3874	0,1145	0,7115	0,2206
Alone_D3			0,9172	0,2121	0,4018	0,1472
DistHomeWS_D2	-0,332	0,0566				
DistHomeWS_D3	0,119	0,0379				
Inc_D2	-1,5585	0,236	0,4988	0,1209	0,8068	0,3165
Inc_D3					0,3391	0,1154
IncNS_D2	-1,4828	0,4212				
IncNS_D3	0,6805	0,2085				
Urb_D2					-0,4054	0,2039
CarAvail_D2	-0,7176	0,2571	-1,4273	0,2018	-0,9492	0,2561
CarAvail_D3	-0,6505	0,1974			-0,6113	0,1195
CUWS_D1	1,9732	0,2263				
CUWS_D2	2,9563	0,2197				
CUWS_D3	1,3264	0,2133				
CUShop_D1			1,0715	0,139		
CUShop_D2			1,0921	0,1514		
CUShop_D3			1,1015	0,3827		
CURecr_D1					0,6144	0,1119
CURecr_D2					1,1492	0,2197
CURecr_D3					0,5025	0,2146
ExpPT_D3	0,4991	0,1627			0,2931	0,1236

5.2.4. Fare evasion model

As already stated, the most common way to interpret the parameters in logistic regression is the interpretation according to the odds ratio (OR). In the odds ratio of gender equals 0.491. This implies that men are more likely to evade fares than women. The odds ratio of age shows that people under 25 years have greater probability to evade fare than people aged above 25 years. This means that the likelihood of fare evasion is higher for younger people than for older people. Like already mentioned before, respondents were asked about their perceptions of prices, checks and fines. The odds ratio of the perception of price represents the ratio of the odds of people with a very high and high perception of tariffs of public transport versus people with correct, low and very low perceptions of tariffs of public transport. This odds ratio equals 0.357, which implies that people with high perceptions of tariffs are less likely to evade fares than people with low perceptions of tariffs. The odds ratio of the perception of checks represents the ratio of the odds of people with a very high, high and correct perception of the amount of checks on fare evasion versus people with low and very low perceptions of the amount of checks on fare evasion. The odds ratio implies that people with high perceptions of the amount of checks on fare evasion are more likely to evade fares than the people with low perceptions of the amount of checks on fare evasion. The odds ratios about the perceptions of fines represents the ratio of the odds of people with a very high and high perception of the magnitude of fines versus the people with a correct, low and very low perception of the magnitude of fines on fare evasion. Both ratios imply that people with a high perception of fines on fare evasion are less likely to evade fare than people with a low perception of fines on fare evasion.

TABLE 5 Parameter Estimates for the Fare Evasion model

		Fare Evasion vs. No Fare Evasion		
Parameter		Estimate	S.E.	OR
Intercept		-0,9978	0,1305	/
Gender	Woman vs. Man	-0,3553	0,0981	0,491
Age	+25 vs. -25	-0,5153	0,1036	0,357
PercPrice	High vs. Low	-0,201	0,0967	0,669
PercChecks	High vs. Low	0,2745	0,1002	1,732
PercBusFine	High vs. Low	-0,2056	0,1035	0,663
PercTrainFine	High vs. Low	-0,3655	0,1294	0,481

6. DISCUSSION

In the previous sections, it was shown that the relationship between the relative prices and the modal choices weren't significant at a 0.05 level. The absence of this relationship between prices of transport and modal choices is in contrast to the study of De Witte et al *(35)* and Agthe and Billings *(54)*. A possible reason for the absence of this relationship could be that the absolute differences in prices of the different scenarios were so minimal, so that the relative difference didn't became fully clear for the respondents. Since there only was a €0.25 difference between scenarios, this difference may perhaps not entirely clear for the respondents.

In contrast to the study of Verheyen *(38)*, where only a zero-price effect for the shopping motive was found, there is found a zero-price effect in the work/school motive and the shopping motive. The zero-price effect for the recreational motive was found insignificant at the 0.05 level, but significant at the 0.10 level. These findings are in accordance with the revealed preference study for students by Steenbergen et al *(37)*, which indicated the modal shift potential of free public transport. The cognitive analysis, which was presented to 50% of the participants, had an unexpected effect on the zero-price effect in the shopping motive. In the study of Shampanier et al *(12)* it was stated, that reliance on cognitive inputs should reduce the zero-price effect. Thus, the group that was subjected to a forced cognitive analysis was expected to show a lower zero-price effect. This study shows a larger zero-price effect in the group that was subjected to a forced cognitive analysis. So we can conclude that the zero-price effect is not driven by the psychological construct affect in this modal choice study.

The most socio-economic variables (e.g. age, gender and living situation) only significantly influence the modal choices in the shopping motive and the recreational motive. The only socio-economic parameter that

significantly influences the modal choice for work or school, as for shopping and recreational motives, is the income parameter of the bike. Remarkably this income parameter of the bike has the opposite effect in the work/school motive than in the other two motives. A low income reduces the likelihood of using the bike in the work/school motive, while it increases the likelihood of choosing the bike in the shopping motive and recreational motive.

The transport-related parameters display a larger influential character than the socio-economic variables, by the magnitude of these parameters. The variable with the largest explanatory power is the current use of modes. In this variable, the modes are captured which the participants use currently for the different motives. The biggest influence of the current use variable is exerted on the work/school motive, followed by respectively the shopping motive and the recreational motive. This indicates that habitual behavior plays a role in this decision making process. This because there is evidence that, when making travel-mode choices, people at least have a strong tendency to "recycle" a decision made in the past *(30)*. When a decision is repeated several times a week in a stable context with the same outcome every time, it is unlikely that much reasoning is involved and is seems highly likely that habitual processes are active in that decision *(55)*. This explains the strength of the explanatory power of the current use variable in the different scenarios. The more the decision is repeated in a stable context, the larger the influence of habitual behavior will be, the larger the parameter estimates of the current use variable will be. For this reason, the parameter estimate of the current use variable is higher in the work/school motive than in the shopping motive and the recreational motive. A strong habit to use a particular travel mode is, in comparison with a weak habit, characterized by seeking less information and a less elaborate choice of travel mode *(56, 57)*. According to this view of habit, a strong habit is perceived to block the more deliberate, cognitive processing prior to behavior *(58)*. This could be an explanation for the larger zero-price effect with participants subjected to a cognitive analysis in the shopping motive. This is because this cognitive evaluation makes a more deliberate, cognitive processing available for the participants, which, in turn, causes the decision making more based on cognitive reasoning instead of habitual behavior. This theory was also confirmed by the study of Eriksson et al *(58)*. This cognitive evaluation, where the car user evaluates the different features of their trip, will not automatically lead to a change in behavior. This evaluation can lead to a continuation of current behavior, but the choice will be more influenced by the personal norm and less by habitual behavior. Another important transport-related parameter is the car availability. In this model this availability of a car reduces the probability of using the bike and public transport significantly in almost all scenarios. This is because the availability of a private car in the household facilitates the choice of car transport and thereby reduces the likelihood of choosing other modes *(30)*. The reason for this, is that car owner have more alternatives than someone without a car and because habitual processes are more important than attitudes for car owners *(30)*. The variable including experience with free public transport has a positive influence on public transport use, which is in accordance with literature. In the study of Fujii and Kitamura *(34)* an experiment was carried out in which a one-month free bus ticket was given to an experimental group. The results showed that attitudes towards bus transport were more positive and that the frequency of bus use increased, whereas the habits of using automobile decreased after the intervention, even one month after the intervention period. The implications of the variables including the distance between home and work or school and the urban environment are quite logical, since the probability of using the bike decreases when travel distance increases. This produces a modal shift towards other modes like public transport. Living in an urban environment reduces the likelihood of choosing the bike, since there are numerous public transport options in a urban environment and the safety of biking is lower in an urban environment.

Given the fact that 25% of the participants indicated that they have evaded fares at least ones, this seems interesting to discuss. The results from the fare evasion model indicate that there is a significant difference in age and gender between people who evade fares and people who do not. In contrast to the findings of Popat *(44)*, income does not play a significant role in fare evasion. This is because the explanatory power of income totally explained by age, which made the variable income insignificant. Next to these variables, some perceptions do play a significant role in fare evasion. People with a high perception of public transport tariffs are less likely to evade fares than people with a low perception of tariffs. A possible explanation can be sought in the age of the fare dodgers. Since people less than 25 years old have higher probabilities to evade fares and since they are more likely to be financially dependent on other people, they could have a reduced cognition of the value of money. This can result in a lower perception of tariffs while they evade fares more. People with high perceptions of the amount of checks are more likely to evade fares then people with a low perception of the amount of checks to counter fare evasion. This is a rather counterintuitive conclusion, but it can be explained by reversed thinking. People who do not evade fares give only minimal, sporadic attention to checks. Thus, they

possibly perceive the amount of checks to be lower than people who actually evade fares. The perception of fines for evading fares in busses and trains have straightforward conclusions. People with a high perception of fines for fare evasion have lower probability to evade fares than people with a low perception of fines for fare evasion. This means that fines have a deterrent effect on fare evasion.

7. POLICY RECOMMENDATIONS

The findings in this paper provide insight in the success and application of a travel demand measure, which aims at changing travel behavior. The modal split potential of an introduction of public transport at a reduced and a zero price was examined. A zero-price effect was found in the work/school motive and the shopping motive at a 5% significance level, and in the recreational motive at the 10% significance level. This implies that the use of public transport will increase significantly when it is provided for free, while a change in relative prices does not provoke significant changes in the modal split because of the insignificance of the price effect. Thus, the subsidizing of public transport with the aim of making it free seems to be a good measure to increase the use of public transport. Subsidizing public transport with the aim of making it less expensive or to change the relative prices with regard to the car does not seem an appropriate measure for policy makers. Important obstacles in the success of this policy measure are the current use of modes for different motives and the car availability. The magnitude of the explanatory power of the current use variable in explaining the modal choices indicates that people least have a strong tendency to recycle a decision made in the past. A policy measure that can counteract this recycling of decisions is the creation of a deliberate, cognitive process prior to the specific behavior. This can be accomplished by informational campaigns which raise the awareness of the different characteristics of the trip, including price or tariffs. Also the car availability plays an important role in the modal choices and could counteract the zero-price effect. To overcome this obstacle, the policy makers have to convince the car owners to interchange their car for public transport. Actions by the Flemish government where a license plate could be interchanged for a free bus pass have proven their success. Thus, combinations of policies with free public transport can further reduce the car availability and increase the market share of the public transport.

A second intent of this paper is to find explanations why people evade fares, since 25% of participants have indicated to have evaded fares once. Out of the socio-economic variables can be concluded that predominantly young people and men have the highest probabilities to evade fares. This means that anti fare evasion campaigns should be focused on this subgroup. Also some perceptions play a significant role in the fact that people evade fares. Fines have proven to be have a deterrent effect when they are perceived to be high. Thus, higher fines can be a measure to reduce fare evasion. These higher fines need to be communicated in a proper way, so that the bus users are aware of the penalties they risk. Also the amount of checks on fare evasion should be maintained. Even though it is not entirely clear from the model, the amount of checks should be maintained at a high level so that people perceive the chance of being penalized as high. So that the fines will maintain or even increase their deterrent effect. The relation between the magnitude of tariffs of the bus transport and fare evasion can be explained by the age of the participants like mentioned above. So this indicates the importance of addressing young, male people in campaigns against fare evasion.

8. CONCLUSIONS AND FURTHER RESEARCH

This study investigated the impact of public transport at a reduced and a zero price on the modal shares in Flanders, Belgium. Results from a mixed logit model indicate that people are not influenced by changing relative prices, but results show a significantly different modal split when free public transport is added to the range of alternatives. This zero-price effect was found to be more significant when people are subject to a cognitive analysis first, where participants were forced to engage in a cognitive and deliberate evaluation of the alternatives. This research finding can be taken into account by policy makers to make the implementation of free public transport more successful. The key variables influencing mode choice appear to be the current use of modes and car availability. Both variables indicate the importance of habitual behavior, which should be taken into account by policy makers when they want to change choice behavior.

However, for further research the absolute value differences and budget changes can be increased to measure the whether a price-effect can be observed. This because, it is implausible that price doesn't affect modal choices. Furthermore, it can be intriguing to develop a revealed preference experiment testing the zero-price effect using a sample in which all sections of the population are represented. Currently, there are, to our

knowledge, only performed revealed preference experiments in Flanders for specific sections of the population (like students).

A second research objective was to find explanatory factors in explaining fare evasion. Gender, age and fines for evading fares seemed to have the most explanatory power in fare evasion. Since these variables are directly or indirectly related with socio-economic features, further research can be done in this class.

REFERENCES

1. Kingham, S., J. Dickinson, and S. Copsey. Travelling to Work: Will People Move Out of Their Cars. *Transport Policy*, Vol. 8, 2001, pp. 151–160.
2. Brög, Werner, Erhard Erl, and Nicola Mense. Individualised Marketing Changing Travel Behaviour for a Better Environment. *Socialdata*, Vol 21, 2002.
3. Jannsens, D., M. Cools, E. Moons, G. Wets, T.A. Arentze, and H.J.P. Timmermans. Road Pricing as an Impetus for Environment-friendly Travel Behavior: Results from a Stated Adaptation Experiment. In *Transportation Research Record: Journal of the Transportation Research Board*, No. 2115, Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 50–59.
4. Steg, L. Can Public Transport compete with the Private Car? *IATSS Res*, Vol. 27, 2003, pp. 27-35.
5. MacKay, D.J.C. *Sustainable Energy - Without the Hot Air*. Cambridge, England, 2009.
6. Thogersen, J. Promoting Public Transport as a Subscription Service: Effects of a Free Month Travel Card. *Transport Policy*, Vol 16, 2009, pp. 335–343.
7. Majumdar, Sarmistha Rina, and Corliss Lentz. Individuals' Attitudes Toward Public Transit in a Rural Transit District. *Public Works Management Policy*, Vol. 17, 2012, pp. 83–102.
8. Borndörfer, Ralf, Marika Karbstein, and Marc E. Pfetsch. Models for Fare Planning in Public Transport. *Discrete Applied Mathematics*, Vol. 160, 2012, pp. 2591–2605.
9. van der Vliet, S. Social Costs and Benefits of 'Free' Public Transport in Dutch Cities. Erasmus University, 2009.
10. Anderson, C. *Free. Hoe Het Nieuwe Gratis De Markt Radicaal Verandert*. Nieuw Amsterdam Uitgevers, 2009.
11. Smith, A., D. Stewart and M. Garnier. *An Inquiry Into the Nature and Causes of the Wealth of Nations*. Bibliobytes, 1825.
12. Shampanier, K., N. Mazar, and D. Ariely. Zero as a Special Price: The True Value of Free Products. *Marketing Science*, Vol. 26, No. 6, 2005, pp. 742–757.
13. Lew, Y. D., and W. Y. Leong. Managing Congestion in Singapore - A Behavioural Economics Perspective. *Journeys (Land Transport Authority, Singapore)*, 2009, pp. 15–22.
14. Szabo, N. Micropayments and Mental Transaction Costs. Presented at *2nd Berlin Internet Economics Workshop*, 1999.
15. Kahneman, D., and A. Tversky. Prospect Theory: An Analysis of Decisions Under Risk. *Econometrica: Journal of the Econometric Society*, Vol. 47, No. 2, 1979, pp. 313–327.
16. Nicolau, J. L. Battle royal: Zero-price effect vs relative vs referent thinking. *Marketing Letters*, Vol. 23, No. 3, 2012, pp. 661-669.
17. Baumbach, E. The Zero-Price Effect - Its Relation to Price Affect and Price-Quality Inferences Regarding Low- and High-Priced Products. Wenen, 2011, PhD Thesis. uniwien.
18. Driouchi, A., Y. Chetioui, and M. Baddou. How Zero Price Affects Demand?: Experimental Evidence from the Moroccan Telecommunication Market. 2011.
19. Finucane, M.L., A. Alhakami, P. Slovic, and S.M. Johnson. The Affect Heuristic in Judgements of Risks and Benefits. *Behavioral Decision Making*, Vol. 13, No. 1, 2000, pp. 1–17.
20. Gourville, J.T., and D. Soman. Overchoice and Assortment Type: When and Why Variety Backfires. *Marketing Science*, Vol. 24, No. 3, 2005, pp. 382–395.
21. Ariely, D., U. Gneezy, and E. Haruvy. Social Norms and the Price of Zero. Working paper, MIT, Boston, MA, 2006.
22. Peine, K., M. Heitmann, and A. Herrmann. Getting a Feel for Price Affect: A Conceptual Framework and Empirical Investigation of Consumers' Emotional Responses to Price Information. *Psychology & Marketing*, Vol. 26, No.1, 2009, pp. 39–66.
23. Zajonc, R. B. Feeling and Thinking: Preferences Need No Inferences. *American Psychologist*, Vol. 35, 1980, pp. 151–175.
24. Zajonc, R. B. On the Primacy of Affect. *American Psychologist*, Vol. 39, 1984, pp. 117–123.
25. Link, Heike, and John Polak. Acceptability of Transport Pricing Measures Among Public and Professionals in Europe. In *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 1839, No. 1, Transportation Research Board of the National Academies, Washington, D.C., 2003, pp. 34-44.
26. Fearnley, N. Inventive Pricing of Urban Public Transport. 2003.

27. Litman, T. Pricing for Traffic Safety. In *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2318, Transportation Research Board of the National Academies, Washington, D.C., 2012, pp. 16–22.
28. Weis, C., K. W. Axhausen, R. Schlich, and R. Zbinden. Models of Mode Choice and Mobility Tool Ownership Beyond 2008 Fuel Prices. In *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2157, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 86–94.
29. Witbreuk, M., and L. de Jong. The Use and Efficiency of Public Transport□: The Effects of Price and Service Measures". Institute of Transport and Logistics Studies. Faculty of Economics and Business. The University of Sydney. 2001.
30. Thorgersen, J. Understanding Repetitive Travel Mode Choices in a Stable Context: A Panel Study Approach. *Transportation Research Part A: Policy and Practice*, Vol. 40, 2006, pp.621–638.
31. Ajzen, I. The Theory of Planned Behaviour. *Organizational behavior and human decision processes*, Vol. 50, No.2, 1991, pp. 179–211.
32. Verplanken, B., and W. Wood. Interventions to Break and Create Consumer Habits. *Journal of Public Policy & Marketing*, 2006, pp. 90–103.
33. Verplanken, B., and H. Aarts. Habit, Attitude and Planned Behavior: Is Habit an Empty Construct or an Interesting Case of Goal-directed Automatic?. *European review of social psychology*, Vol. 10, No. 1, 1999, pp. 101–134.
34. Fujii, S., and R. Kitamura. What Does a One-month Free Bus Ticket Do to Habitual Drivers?. *Transportation*, Vol. 30, No.1, 2003, pp. 81–95.
35. De Witte, A., C. Macharis, and O. Mairesse. How Persuasive Is 'Free' Public Transport? A Survey Among Commuters in the Brussels Capital Region. *Journal Transport Policy*, Vol. 15, 2008, pp. 216–224.
36. Boyd, B., M. Chow, R. Johnson, and A. Smith. Analysis of Effects of Fare-Free Transit Program on Student Commuting Mode Shares. In *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 1835, Transportation Research Board of the National Academies, Washington, D.C., 2003, pp. 101-110.
37. Steenberghen, T., P. Lannoy, and C. Macharis. Impact of" free" public transport on travel behaviour: a case study. 2006.
38. Verheyen, G. Irrationaliteit in Vervoerswijzekeuze: Gratis. Hasselt: Universiteit Hasselt, 2010.
39. Brueckner, J.K. "Transport Subsidies, System Choice, and Urban Sprawl. *Regional Science and Urban Economics*, Vol. 35, 2005, pp. 715–733.
40. Reddy, A. V., J. Kuhls, and A. Lu. Measuring and Controlling Subway Fare Evasion. *Transportation Research Record: Journal of the Transportation Research Board* Vol. 2216, Transportation Research Board of the National Academies, Washington, D.C., 2011, pp. 85–99.
41. Bijleveld, C. Fare Dodging and the Strong Arm of the Law. *Journal of Experimental Criminology*, Vol. 3, No. 2, 2007, pp. 183–199.
42. Clarke, R.V., S. Contre, and G. Petrossian. Deterrence and Fare Evasion: Results of a Natural Experiment. *Security Joural*, Vol. 23, No. 1, 2010, pp. 5–17.
43. Dauby, L., and Z. Kovacs. Fare Evasion in Light Rail Systems. *Transportation Research E-Circular*, 2007.
44. How To Resolve The Transit Fare Evasion Problem. Popat, I. http://politicsrespun.org/2012/05/how-to-resolve-the-transit-fare-evasion-problem/. 2012.
45. Declercq K., D. Janssens and G. Wets. Travel Behavior Research Flanders 4.3 (2010-2011): Table Report. Hasselt University, Diepenbeek, Belgium, 2012
46. Hensher, D. A. Stated Preference Analysis of Travel Choices: The State of Practice. *Transportation*, Vol. 21, 1994, pp. 107–133.
47. Kroes, E. P., and R. J. Sheldon. The use of attitude models and stated preference models in practical transport analysis. *Behavioural Research for Transport Policy*, 1986, pp. 307–326.
48. Wardman, Mark. A Comparison of Revealed Preference and Stated Preference Models of Travel Behaviour. *Journal of Transport Economics and Policy*: 1988, pp. 71–91.
49. DeMoranville, C.W., and C.C. Bienstock. Question Order Effects in Measuring Service Quality. *Journal of Research in Marketing*, Vol. 20, 2003, pp. 217–231.
50. De Ceuster, G. Internalisering van externe kosten van wegverkeer in Vlaanderen. Transport & Mobility Leuven, Leuven, 2004, pp. 12-13.

51. Hoffman, S. D., and G. J. Duncan. Multinomial and Conditional Logit Discrete-Choice Models in Demography. *Demography*, Vol. 25, No. 3, 1988, pp. 415–427.
52. Hosmer, D. A., and S. Lemeshow. Model-Building Strategies and Methods for Logistic Regression Second edition. John Wiley & Sons, Inc., Hoboken, NJ, USA, 2005.
53. Agresti, A. *Building and Applying Logistic Regression Models, in Categorical Data Analysis.* John Wiley & Sons, Inc., Hoboken, NJ, USA, 2003.
54. Agthe, D. E., and R. B. Billings. The Impact of Gasoline Prices on Urban Bus Ridership. *The Annuals of Regional Science*, Vol. 12, 1978, pp. 90–96.
55. Wood, W., J.M. Quinn, and D.A. Kashy. Habit in Everday Life: Thought, Emotion, and Action. *Journal of Personality and Social Psychology*, Vol. 83, 2002, pp. 1281–1297.
56. Aarts, H., B. Verplanken, and A. Van Knippenberg. Habit and Information Use in Travel Mode Choices. *Acta Psychologica*, Vol. 96, 1997, pp. 1–14.
57. Verplanken, B., H. Aarts, and A. Van Knippenberg. Habit, Information Acquisition, and the Process of Making Travel Mode Choices. *European Journal of Social Psychology*, Vol. 27, 1997, pp. 539–560.
58. Eriksson, L., J. Garvill, and A.M. Nordlund. Interrupting Habitual Car Use: The Importance of Car Habit Strength and Moral Motivation for Personal Car Use Reduction. *Transportation Research Part F*, Vol. 11, 2008, pp. 10–23.

ANNEX A : Descriptive statistics

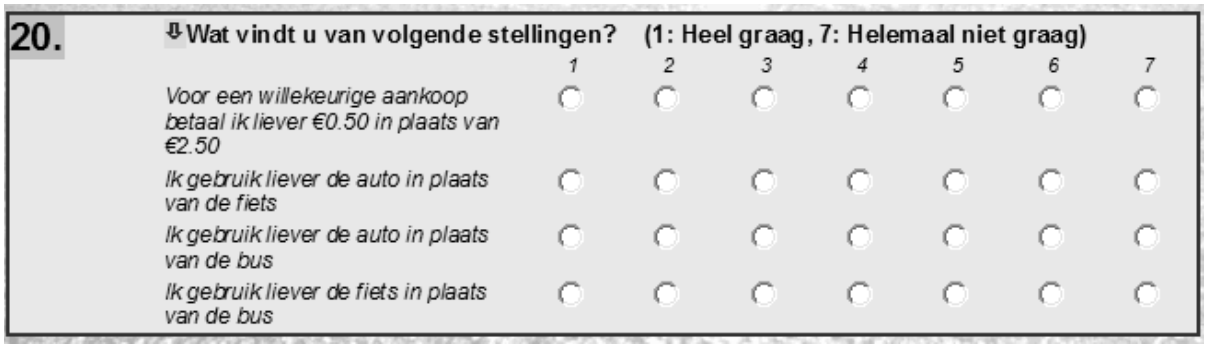
In the table below the descriptive statistics of the variables that are used in the models are displayed. Firstly, the dependent variables are displayed. The market shares for the different motives and the different price scenarios are displayed below. The following socio-demographic variables were considered: gender, age, living situation, income and urbanization. In addition, transport-related variables were considered; distance from home to work or school, car availability, the current use of modes for work or school trips, for shopping trips and for recreational trips and the experience with free public transport.

Descriptive statistics

Variable name	Description	
Dependent variables		
Work/School	Situation A:	Car: 38,30%, Bike: 26,92%, Public Transport: 34,78%
	Situation B:	Car: 37.18%, Bike: 27.88%, Public Transport: 34.94%
	Situation C:	Car: 35.42%, Bike: 24.84%, Public Transport: 39.74%
Shopping	Situation A:	Car: 66.42%, Bike: 28.36%, Public Transport: 5.22%
	Situation B:	Car: 66.27%, Bike: 27.76%, Public Transport: 5.97%
	Situation C:	Car: 63.28%, Bike: 25.52%, Public Transport: 11.19%
Recreational	Situation A:	Car: 64.18%, Bike: 5.52%, Public Transport: 30.30%
	Situation B:	Car: 63.43%, Bike: 6.27%, Public Transport: 30.30%
	Situation C:	Car: 60.00%, Bike: 4.78%, Public Transport: 35.22%
Independent variables		
Socio-demographic characteristics		
Gender	Female: 47.76%, Male: 52.24%	
Age	Mean: 31, Standard Deviation: 15,41	
Living situation	Alone: 12,09%, Other: 87,91%	
Income	Low (No Income and < €1500): 57,91%, High (> €1500): 31,79%, Unspecified:10,30%	
Urbanization	No: 44.78%, Yes: 55.22%	
Transport-related characteristics		
Distance home-work/school	0-10 km: 41,35%, 10-20 km: 21,96%, 20-30 km: 17,95%, 30-50 km: 13,14%, >50 km: 5,61%	
Car Availability	Always: 43.43%, Usually: 19.85%, Sometimes: 17.01%, Rarely: 7.76%, Never: 11.94%	
Current Use Work/school	Car: 43.43%, Bike: 22.92%, Public Transport: 29.33%, Other: 4,32%	
Current Use Shopping	Car: 60.00%, Bike: 24.48%, Public Transport: 1.79%, Other: 13,73%	
Current Use Recreational	Car: 57.76%, Bike: 26.27%, Public Transport: 5.67%, Other: 10,3%	
Experience Free Public Transport	No: 1.94%, Yes: 98.06%	

ANNEX B: Cognitive Analysis

Like explained above, the cognitive analysis forces the respondent to think about different prices and different modes of transportation. First the respondent is asked how much he prefers to spend less. Then the respondent is forced to make an internal comparison of the different modes. Thinking about these questions will force the respondent to make an internal cognitive analysis of the offers presented in the questionnaire. It is expected that the respondent subjected to this cognitive analysis will act in a more cognitive way then the respondent who isn't subjected to this cognitive analysis.



20. ⇩**Wat vindt u van volgende stellingen? (1: Heel graag, 7: Helemaal niet graag)**

	1	2	3	4	5	6	7
Voor een willekeurige aankoop betaal ik liever €0.50 in plaats van €2.50	○	○	○	○	○	○	○
Ik gebruik liever de auto in plaats van de fiets	○	○	○	○	○	○	○
Ik gebruik liever de auto in plaats van de bus	○	○	○	○	○	○	○
Ik gebruik liever de fiets in plaats van de bus	○	○	○	○	○	○	○

ANNEX C: Model results of the shopping model for the subgroup that was subjected to a cognitive analysis

Parameter	DF	Estimate	S.E.	t-value	Approx Pr>|t|
Bike_D2	1	-0.4234	0.8409	-0.50	0.6146
PT_D3	1	-0.9942	0.8609	-1.15	0.2482
RelCostShop	1	0.5070	0.9693	0.52	0.6009
Free	1	1.0572	0.2778	3.81	0.0001
Inc_D2	1	0.3093	0.1650	1.87	0.0609
CarAvail_D3	1	-1.2939	0.2777	-4.66	<.0001
Man_D2	1	0.3676	0.1575	2.33	0.0196
Alone_D3	1	0.9568	0.3120	3.07	0.0022
CUShop_D1	1	1.0972	0.1958	5.60	<.0001
CUShop_D2	1	1.0903	0.2200	4.96	<.0001
CUShop_D3	1	1.7366	0.6358	2.73	0.0063

ANNEX D: Model results of the shopping model for the subgroup that was not subjected to a cognitive analysis

Parameter	DF	Estimate	S.E.	t-value	Approx Pr>|t|
Bike_D2	1	-1.5706	0.8859	-1.77	0.0762
PT_D3	1	-1.4844	0.8930	-1.66	0.0965
RelCostShop	1	-0.2726	1.0117	-0.27	0.7876
Free	1	0.6376	0.2743	2.32	0.0201
Inc_D2	1	0.7226	0.1792	4.03	<.0001
CarAvail_D3	1	-1.5693	0.2994	-5.24	<.0001
Man_D2	1	0.4331	0.1679	2.58	0.0099
Alone_D3	1	0.8509	0.2943	2.89	0.0038
CUShop_D1	1	1.0661	0.1992	5.35	<.0001
CUShop_D2	1	1.1185	0.2113	5.29	<.0001
CUShop_D3	1	0.7229	0.5173	1.40	0.1623

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Fabbro, Yannick

Datum: **27/05/2013**