A nested logit model for instantaneous travel mode choice analyses in the Oslo area

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Abstract:
We present a nested logit model for travel mode choice analyses estimated on survey data for short distance trips in Oslo and the surrounding county Akershus. Despite the relative high number of choice alternatives (9), model parameters (120) and observations (close to 15,000) it was shown feasible to implement the model in Microsoft-Excel allowing for simple scenario analyses. New market shares are calculated in the implemented model instantaneously by the method of sample enumeration.
Another notable feature of the model is the distinction between trips in train, bus and metro/tram. This is a new element to Norwegian short distance travel demand modelling where public transport has traditionally been handled as a common alternative.
With a case study on free public transport services, we illustrate that the model is capable of producing reasonable results for the whole market and different submarkets (geographical sub-regions, trip purposes and trip distance segments). One of the insights gained from the model is that there is a rather strong substitution pattern ("cannibalism") between different forms of public transportation in the Oslo Area.

1. Introduction

This paper is motivated by the fact that many travel demand models are structurally so complicated and/or computational so demanding that they require to be implemented in specifically designed software. This limits the accessibility of the models to researcher trained in the particular software. For many transport planners the lack of possibility to test the effect of policy scenarios themselves may furthermore increase a common skepticism towards such transport models and their results. To give an example for the Norwegian case, the network based model system RTM (Madslien et al 2005)[1], which iterates between the demand model TraMod_By (Rekdal et al 2012) and a static traffic assignment model, is implemented in Cube (http://www.citilabs.com/). Conducting scenario analyses with RTM is rather demanding both in respect to human capital (as it requires researchers/consultants trained in Cube) and in respect to computational times (taking several hours to produce a result). This sets practical limits to ad-hoc analysis often demanded by researchers and stakeholders to test and compare the effects of policy measures and the pre-select measures for more detailed (and more dimensional) analyses.

This paper presents an easily accessible and user-friendly travel mode choice model (hereafter referred to as MPM23[2]). The model omits other behavioral dimensions of travel demand like car accessibility, trip frequency, destination choice, choice of departure time and route choice, and holds travel supply and traffic flow constant (exogenous). This makes MPM23 structurally and computationally much less demanding compared to RTM. Indeed, it was possible to implement the model in Microsoft-Excel allowing for ad-hoc and quick scenario analyses.

MPM23 was commissioned by Ruter AS, the management company for public transport in Oslo and Akershus.[3] Besides the improved accessibility of the model compared to RTM, the model development was motivated by the underlying data, Ruter's market information systems (MIS) that allowed including specific variables in the mode choice model. One of these variables is an indicator variable for traveler's general satisfaction of public transport. An inclusion of this variable in a predictive model – despite methodological caveats – allows for some additional analyses that can complement results obtained from RTM. Another feature of MPM23 is that it distinguishes between trips in train, bus and metro/tram whereas other Norwegian short distance travel demand models have traditionally handled public transport as a common alternative. For instance, in RTM the distinction into different forms of public transport is first made in the network assignment part, the "last" model component of the 4(5)-step model system[4]. Splitting up into public transport alternative allows investigating the substitution patterns between different forms of public transportation and provides some new insights.

The survey data of Ruter's MIS has not been used for full-fletched travel mode choice analyses prior to MPM23. Consultants Urbanet (2013) used Ruter's MIS to identified drivers for taking public transport to work applying a simple binary logistic regression model. MPM23 improves in several ways on that work: (1) we specify choice set with 9 different travel alternatives, (2) we import Level-of-Service data based on geographical information in MIS (available after July 2014), (3) we specify and estimate a nested logit model, (4) we implement the estimation model in Microsoft-Excel where new choice probabilities are calculated by sample enumeration and (5) the spreadsheet model allows

[1] RTM (Regional Transport Model) is part of the transport authority's common model system and regularly used for transport planning purposes as e.g. for the Norwegian National Transport Plan.
[2] The acronym MPM23 stands for "market potential model for Akershus and Oslo". The county Akershus is typically numbered as 2 and Oslo as 3 among the 19 counties in Norway. The model version of RTM adjusted to these two counties (and a few districts in addition) is called RTM23+.
[3] Ruter AS is owned by 60% by the city/county Oslo and by 40% by the county Akershus that surrounds Oslo.
[4] RTM can be regarded as an improved version of the classical (static, macroscopic and deterministic) 4-step model, where an additional model component (car accessibility model) is included and where destination and mode choice is modelled in a combined choice model. See Flügel et al 2014 for a discussion of the methodology of RTM.

for convenient scenario analysis. The model also includes several dummy variables that allow capturing the heterogeneity in choice probabilities (market shares) across submarkets (trip purpose, trip distance and geographical zones) within the short-distance travel market in the Oslo area.

In the literature, many transport-related logit models can be found where choice probabilities or elasticities are calculated/predicted by the method of sample enumeration. First models are reported at end of the seventies and - according to Daly (1982) - the expression “sample enumeration” goes back to Ben-Akiva and Atherton (1977). Some of the later reported models are also implemented as a spreadsheet model allowing for scenario analyses.
Ewing and Sarigöllü (1998), for instance, develop a stated-preference (SP) based multinomial logit model (MNL) for car fuel-type choice and calculate new choice probabilities by sample enumeration using spreadsheet. Adler et al (2010) report a MNL estimated on SP-data for ferry demand where the spreadsheet model calculates fare elasticities by sample enumeration.
It is likely that more (published and unpublished) spreadsheet models of that kind exist. We are not aware of spreadsheet models for short-distance travel mode choice based on (revealed preference) survey data prior to MPM23.

This paper is based on the following report (in Norwegian): “Markedspotensialmodell for Oslo og Akershus (MPM23) – Dokumentasjon og brukerveiledning for versjon 1.0” by Flügel et al (2015).[5] The reminder of the paper is structured as follows: In section 2, we describe the methodology of the model. Section 3 is about the data set and the data preparation done upfront the estimation of the model presented in section 4. Section 5 briefly presents the implemented model (version 1.1.) and in section 6 presents a case study on free public transport in Oslo area. Section 7 concludes and briefly outlines ways to improve the model.

[5] The report includes a description and user manual of version 1.0 of MPM23. In this paper, we use version 1.1., which has some extended functionality in the Excel-based predictive model. The data and methodology of the estimation- and predictive model is the same for version 1.0 and 1.1.

2. Method

Most travel mode choice models - as stand-alone models or as part of a model systems as in traditional “four-step-models” - are discrete choice models (DCM), i.e. models where decision makers (here travelers) choose one (and only one) alternative from a choice set of finite, mutually exclusive and exhaustive alternatives according to a well-defined choice rule. While discrete choice models go back to Thurestone (1927) their breakthrough in the practice of transportation science is due to the rise of the logit model in the early seventies (McFadden 1974). Logit models, at least in the original multinomial logit (MNL) and nested logit (NL), have a great practical advantage over the other DCM (like Thurstone’s Probit Model) that choice probabilities can be calculated numerically (in “closed form” without taking integrals). This is not only handy for parameter inference but also for model prediction. With improved computer accessibility in the late seventies, the convenient “closed form” of the MNL and NL made it feasibly to build predictive models where (new) choice probabilities are calculated for individual decisions makers (i.e. by sample enumeration). Individuals in sample enumeration are typically those observations also used to estimate the coefficient of the underling model.

The advantage of sample enumeration compared to aggregated methods of prediction (as the typical market segmentation approach also used in RTM)[6], is that it avoids aggregation biases (se e.g. Ben-Akiva and Lerman 1985). Another advantage is that results can be aggregated over the desired dimensions after the model is run while with aggregated methods of prediction one is constraint to the a-prior segmentation applied in the model
For presentation and interpretation, disaggregated results from sample enumeration (individual choice probability) are typically aggregated over choice alternatives, often into so-called average choice probabilities, ACP (Ewing and Sarigöllü, 1998). While not being immediately identical to market shares, ACP can be thought of the market share distribution that is expected to occur from a choice simulation process with sufficient high observations.[7] E.g. if there are 1 million decision makers in the real world and the sample exist of 1000 respondents, simulating each observation 1000 times yields to simulated market shares that – in approximation – equal the calculated ACP from sample enumeration. The validity of calculated ACP clearly rest on to degree of which the sample is representative for the real world population. Indeed, representativeness is arguably the biggest challenge with basic sample enumeration.
As samples typically get more representative with increased number of observations, a large sample size is considered important for the precision of results obtained with sample enumeration. The current version of MPM23, we have close to 15,000 observations, which is regarded relative high for our context. However, the number of observations for some sub-markets is low and motives considering more advanced methods of creating the sample for the predictive model (as e.g. population synthesis discussed in section 8).

We apply a nested logit model (Williams 1977, Daly and Zachary 1978) where choice probabilities (*Pr*) for an observation (here individual trip) (*n)* of choosing travel mode (*i)* - among all travel modes (*j*) part individual/choice situation specific choice set (C_n) are given as:

[6] In RTM, one divides the population into user segments and OD-relations. The total number of trips departing from each network zone is divided between the different modes of transport using a logit model. An aggregated predictive model based on model segmentation always involves some degree of aggregation bias. The coarser the segmentation, the higher the (expected) aggregation bias.
[7] We refer “simulate” to taking random draws from the error term of the underlying logit model.

$$(1)\quad \Pr_n(i \in C_n) = \frac{\left(\sum_{j=1}^{Jm} e^{\mu_m V_{nj}}\right)^{\frac{1}{\mu_m}}}{\sum_{m=0}^{M} \left(\sum_{j=1}^{Jm} e^{\mu_m V_{nj}}\right)^{\frac{1}{\mu_m}}} * \frac{e^{\mu_m V_{ni}}}{\sum_{j=1}^{Jm} e^{\mu_m V_{nj}}},$$

In equation one, *m* identifies the nests and $\mu_m \geq 1$ represents the scale parameters of nest *m*[8]. V_{ni} are systematic utility functions, in our case specified in a simple linear-in-parameter fashion:

$$(2)\quad V_{ni} = \beta_{o,i} + \sum_k \beta_{k,n,i} X_{k,n,i}$$

with $X_{k,n,j}$ being the explanatory variables of the model (indexed *k*), $\beta_{k,n,i}$ the corresponding coefficients representing the marginal effect of explanatory variables and $\beta_{o,i}$ being alternative specific constants capturing the average effect of the error terms $\varepsilon_{n,j}$ of the underlying choice rule (3).

$$(3)\quad V_{ni} + \varepsilon_{n,i} > V_{nj} + \varepsilon_{n,j} \quad for\ all\ j = C_n.$$

In NL the error term of alternatives of the same nest are positive correlated and the correlation increases with μ_m. The researcher has to specify the nesting structure prior to estimation and needs to revise the specification in case values of μ_m are found smaller than 1. When all values of μ_m are found to be 1 the NL model collapses to a MNL where error terms are uncorrelated to each other.

To make things concrete, the remainder of this section outlines the specification of choice alternatives, choice sets and explanatory variables of MPM23.

In MPM23 choice alternatives, j=1...9, are given as:

1. **Car driver** (not as access mode to/from public transport station)
2. **Car passenger** (not as access mode to/from public transport station)
3. **Walk** (not as access mode to/from public transport station)
4. **Cycle** (not as access mode to/from public transport station)
5. **Train** (without switching to other forms of public transport)
6. **Bus** (without switching to other forms of public transport)
7. **Metro/tram** (without transfer to forms of other public transport)
8. **Combination with train** (public transport with transfers between forms of public transport: at least one (of several) travel modes is train)
9. **Combination with bus and metro/tram** (public transport with transfers between forms of public transport: none of them train)

Choice sets (C_n) depend on the situational context of the trip. After some testing, we used the following criteria to specify when an alternative is available:

- Car drivers must have access to a car and need a driver's licence (information is available for each observation in Ruter's MIS).
- For Walk (Bicycle) to distance from origin to destination (OD) may not exceed 10 (40) km (this information comes from network based Level-of-Service (LoS) data imported based on geographical information in Ruter's MIS, see next section)
- Public transport:

[8] In (1) we have normalised the overall scale of utility μ to 1. In NL models μ can be interpreted as the scale in choices between nests. Note also that the first expression in (1) represents the choice probability of the choice between nests while the second expression represents the choice between alternative of the same nest.

- OD-relations for which LoS could be imported (LoS data is not available for trips that started and ended in the same geographical zone)[9]
- Distance from/to public transport stations must be under 2.5 km for trips within Oslo and 7.5 km for trip within Akershus or between Oslo and Akershus.

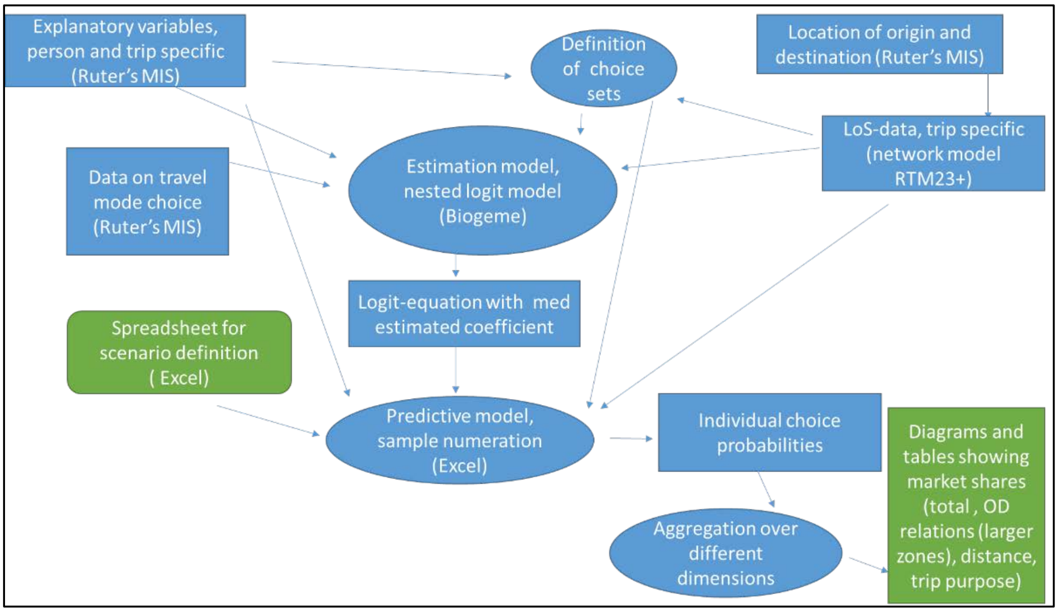
Explanatory variables, $X_{k,n,i}$, (in more detail described in section 4 and 5) include:

- (continuous) LoS variables:
  - travel costs
  - invehicle time
  - waiting time
  - access/egress time
  - number of interchanges
  - trips distance (for walk and cycle)
- Dummy variables
  - Trip purposes
  - Geographical OD pairs (large zonal system consisting of 7 zones)
  - Free parking
  - Satisfaction with public transport
  - Gender
  - Season (April to September)

Based on observed ("reavealed") travel mode choices in Ruter's MIS (see next section), the situational dependent choice sets and explanatory variables, we estimate the parameters of equation (1) and (2). The collective information is then the basis for the implemented model in Microsoft-Excel where individual choice probabilities are calculated by sample enumeration. Figure 1 illustrates the general methodology and data flow of the model development.

[9] The network model RTM23+ has a detailed zonal system of 1941 zone for Oslo and Akershus (2741 zones including additional areas not covered in MPM23). 77% (90%) of these zones have a radius of less than 1km (2km).

Figure 1: Illustration of methodology and data flow in MPM23



The green marked fields in Figure 1 are those visible to user of the spreadsheet model. That is the user defines scenarios by specifying percent changes in explanatory variables and the spreadsheet model immediately (by means of some few seconds) produces results in form of diagrams and tables. Those show markets shares for the reference scenario (all explanatory variables hold to the initial values) and a policy scenario (with the applied changes in explanatory variables) for the whole market of Oslo/Akershus and segmented into different submarket (see section 5).

3. Data

Ruter's MIS is a travel survey on short distance trips in Oslo and the surrounding county Akershus administrated by Ruter AS. Starting in 2006 around 6,000 interviews are continuously conduced each year. Respondents are selected by a dynamic quota sampling and contacted by phone. The interviews include questions about habits, attitudes and impressions of public transport in Oslo/Akershus and ask for typical individual-specific information (age, gender, access to car etc.). In addition, a large part of the survey is framed around obtaining information about respondent's trips made the day before the interview is conducted. The related questions ask about the purpose of travel, travel mode choice and - since summer 2014 - the location of departure and destination. Regarding travel modes, respondents are asked to state the first and second (and if relevant third, fourth and fifth) travel mode used for each of yesterday's trips.
As there are very few observations with more than two travel modes on the same trip, we conveniently defined choice alternatives for modelling by the first two reported travel modes (for close to half of trips only one travel mode is reported). Excluding observation that choose minor transport modes (motorcycle / moped / boat / ferry / airport express) led to our definition of nine choice alternative specified in section 2. Table 1 shows how often these nine choice alternatives were chosen (in reality) and specified as available (by the model given criteria mentioned in section 2).

Table 1: Chosen alternatives and specified availability

	Chosen in reality		Specified available in the model	
Choice alternative	**Number in sample**	**Column percent**	**Number in sample**	**Share of total number**
Car driver	7143	47.8%	11953	80.0 %
Car passenger	521	3.5%	14947	100.0 %
Walk	3256	21.8%	11176	74.8 %
Cycle	769	5.1%	14506	97.0 %
Train	455	3.0%	3163	21.2 %
Bus	1143	7.6%	9257	61.9 %
Metro/tram	1216	8.1%	4252	28.4 %
Combination with train	258	1.7%	2217	14.8 %
Combination with bus and metro/tram	186	1.2%	1909	12.8 %
Total	14947	100.0%		

The numbers in Table 1 related to the final sample of the model. For the final sample, we excluded observations from the original data set that:

- Started or ended outside Oslo and Akershus
- Had missing or invalid geographical information (this includes all observations before August 2014)
- Data from August 2014 (to get a representative sample for a whole year from September 2014 until August 2015)
- Observations where the actual travel mode choice was defined as not available by the model (this last exclusion rule decrease the sample size from 15825 to 14947 observations, that is by 5.5%)

The need for geographical information about the OD of trips is crucial for the identification of LoS-data. With revealed preference data one typically needs to import LoS-data from external data sources because LoS (at least for the non-chosen alternatives) is not available in survey data. In our case, the geographical information was used to import LoS for all travel alternatives from the network model RTM (more specifically "RTM23+" the model version of RTM adjusted to the Oslo-region).

Dividing the common alternative "public transport" into five different choice alternatives is most meaningful when specific LoS-data can be important for all choice alternatives. This is no obvious task as the network assignment tool in RTM23+[10] produces by default LoS-data for a common alternative "public transport". By switching off transport mode from the network model, we seemingly managed to isolate LoS-data for the five (mutually exclusive) travel alternatives within "public transport".[11]

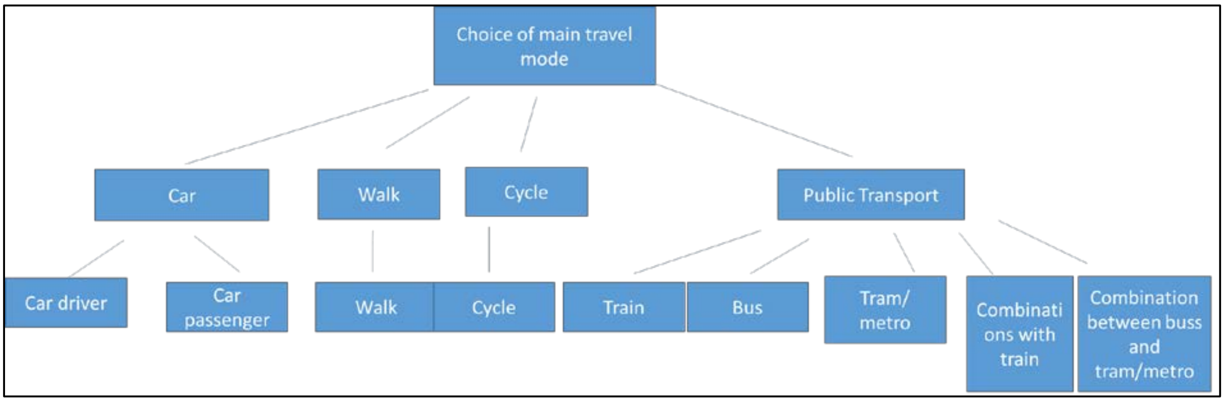
Unfortunately, Ruter's MIS does not include information about the departure time of trips. Therefore, we had to assign time-dependent LoS-data (one set of matrices for rush-traffic and one set for non-rush traffic) randomly to single trips in Ruter's MIS. With the idea to improve precision slightly, we used external information about the share of traffic done in rush per travel purpose in the random assignment procedure. E.g. a commuting trip got a higher probability of getting assigned the LoS-data for rush compared to e.g. shopping trips.

4. Estimation

The final selection and specification of explanatory variables entering the utility functions of MPM23 was made after running over 100 test models. We experienced challenges in getting correct sign of some few LoS-variables. One problem occurred for car cost and time that are naturally highly correlated. We also had to include dummy variables for distance groups in the utility function for "train" and "combination with train". Without controlling for distance the natural propensity of taking train for those OD-pair farer apart (having relative long invehicle times) would have resulted in a positive coefficient for invehicle time in train. This would have led to counterintuitive results in scenario analysis. Despite the challenges, we manged to find a model specification where the sign of all 120 model parameters followed expectation/were reasonable.

The applied nested structure of the MPM23 is illustrated in Figure 2.

Figure 2: Structure of nested logit model for MPM23



For the degenerated nest walk and cycle the scale parameter is hold constant at unity.

[10] In RTM23+, EMME is used (while Cube Voyager is used for the remaining RTM models in Norway)
[11] The so-called «select-line-macro» i EMME was used for this purpose. E.g. for establishing the LoS-data for choice alternative Train (without switching to other public transport)" all other modes than train were filtered out from the transport network. Details of the technical procedure are described in Angell (2015).

Inference of the other scale parameters ("nest parameters") as well as all coefficients of the systematic utility functions is performed with Biogeme (Bierlaire 2003, Bierlaire 2008), an popular estimation tool for logit models based on the maximum likelihood method.

Table 2 summarises the estimation results.

The continuous variable travel distance enters the utility functions for both walk and cycle. The corresponding coefficients (the marginal effect of longer distance on utility) is significantly negative and the marginal effect is – as expected - stronger for walk than for cycle.

The coefficients for monetary travel costs are significantly negative; the value is somewhat lower (less negative) for public transport compared to car. Note that travel cost for cars comprehensive only fuel costs and road tolls (no insurance, maintenance costs etc.). Regarding public transport, we have set the marginal ticket price for respondents with monthly/seasonal tickets to zero. This assumption is further elaborate on in section 6.

Most of the coefficients for the different travel time components are highly significant but there relative values compared to the cost coefficient are rather low. Table 3 shows the implicate Value of Time (VOT) measures in MPM23 and compares it with values obtained in the Norwegian Value of Time study (Ramjerdi et al 2010, Halse et al 2010). Methodology differences between the studies and differences in the sampling (the Norwegian Value of Time study included only trips over 10 minutes) might explain some of the differences. However, it is also likely that the above-mentioned challenges regarding correlation have cause the implicit VOT values to be somewhat lower than expected.

The dummy for "satisfaction with public transport" is coded 1, when respondents replied "very satisfied" or "pretty satisfied" on the survey question "In general, how satisfied are you with the public transport service [where you live and travel]?" As expected, the coefficients entering the utility functions of public transport alternatives are estimated to be positive. To lowest effect is found for the train alternative. For the interpretation of the size of the effects, it is important to remember that the model controls for the Level-of-Service of public transport when estimating these coefficients. For policy analysis, varying the share of respondents that are satisfied, the resulting effect should therefore be interpreted as the effects of changed satisfaction related to soft (unobserved) factors of public transport services (information services, cleanness on stations etc.). As - one the other hand - the coefficient for LoS are controlled for the level of satisfaction we checked how the LoS-coefficients change in a model version where the "satisfaction-dummies" are excluded. The LoS-coefficients changed only slightly in size and the goodness of fit of the model did barely decrease.[12] Other methodological concern with this variable is possible endogeneity, i.e. that the travel mode choice effects the level of satisfaction (and not only the other way around as postulated in the model). This might lead to on overestimating of the effect of satisfaction on utility. We did not investigate this further as the general impression of the demand effect of "satisfaction" was regarded in generally as low (see discussion in section 8).

The coefficient for dummy variable "free parking" in the utility function for car drivers is significantly positive. Note, that fewer free parking spots will therefore reduce the choice probability for car driver but c.p. increase the probability of car passengers (increase car sharing).

[12] Indeed, the rho-square measure, as well as the adjusted rho-square measure, remained the same for the first three digits reported in Biogeme.

Table 2: Estimation results for parameters in MPM23

Number of observations	14943	Null-LL	-23356.264	
Number of parameter	120	Final-LL	-12204.193	
Adj. Rho square	0.472			p-value 0 ***< 0.01; **<0.05; *<0.2

Modell indeks: V343		Choice alternatives								
	Corresponding explanatory variables	**Car driver**	**Car passanger**	**Walk**	**Cycle**	**Train**	**Comb. With train**	**Bus**	**Metro/Tram**	**Comb. With bus and metro/tram**
LoS	Distance (km)			-0.757***	-0.206***					
	Travel costs (NOK)	-0.0323***				-0.0472***				
	invehicle time (min)	-0.0184***				-0.0252***		-0.02***	-0.0241***	-0.0276***
	acess/egress time (min)					-0.0398***		-0.046***	-0.059***	-0.0454***
	waiting time (min)					-0.0453***		-0.0253***	-0.026**	-0.0165*
	number of boardings					-0.162**		-0.448***	-0.372***	-0.452***
ASC		0 (norm)	-2.63***	2.86***	-0.562***	2.01***	1.43***	2.18***	2.66***	2.22***
Dummy variable for trip purposes	commuting trips	-0.390***	-0.927***	-0.579***	0.415***	0 (norm)				
	school trips	-1.04***	-1.18***	-1.280***	-0.177	0 (norm)				
	trips within working hours	-0.19	-0.076	-1.500***	-0.766	0 (norm)				
	grocery shopping	0.733***	0.0183	-0.273**	-0.0382	0 (norm)				
	bringing/picking up someone	1.500***	-0.308	0.217	0.498**	0 (norm)				
Dummy variables for larger zone relations	Oslo centrum<->Oslo centrum	0 (norm)				0 (norm)				
	Oslo centrum<->Oslo west	0.843***				0.819**				
	Oslo centrum<->Oslo north/east	0.93***				0.926**				
	Oslo centrum<->Oslo sør	0.67***				0.947**				
	Oslo centrum<->BærumAsker	0.897***				0.663*				
	Oslo centrum<->Rømerike	0.154				0.537				
	Oslo centrum<->Follo	-0.192				0.61*				
	Oslo west<->Oslo west	1.320***				-2.12***				
	Oslo west<->Oslo north/east	1.300***				1.11**				
	Oslo west<->Oslo south	1.26***				1.17**				
	Oslo west<->BærumAsker	1.48**				0.849**				
	Oslo west<->Romerike	1.04***				0.832*				
	Oslo west<->Follo	0.82*				0.3				
	Oslo north/east<->Oslo north/east	1.48***				-6.18***				
	Oslo north/east<->Oslo south	2.05***				1.05**				
	Oslo north/east<->BærumAsker	1.62***				0.665				
	Oslo north/east<->Romerike	2.21***				0.254				
	Oslo north/east<->Follo	2.800***				1.07*				
	Oslo south<->Oslo south	1.69***				-5.83***				
	Oslo south<->BærumAsker	1.84***				0.387				
	Oslo south<->Rømerike	2.85***				1.21**				
	Oslo south<->Follo	2.51				1.17				
	BærumAsker<->BærumAsker	2.1***				0.515				
	BærumAsker<->Rømerike	2.21***				1.15*				
	BærumAsker<->Follo	0.71				0.347				
	Rømerike<->Rømerike	2.02***				0.63*				
	Rømerike<->Follo	1.92**				0.307				
	Follo<->Follo	2.03***				0.96**				
Dummy for trip distance	under 5 km					-0.956***				
	5-10km					-0.711***				
	10-20km					-0.418**				
	20km-30km					-0.0832				
	over 30km					0 (norm)				
Other dummy variables	Satisfied with public transport					0.181*	0.31***	0.343***	0.294***	0.287***
	Free parking	0.538***								
	April-September			0.0546	0.848***					
	female		0.744***							
	trips starts/ends in same zone			1.06***	0.584***					
Nest parameter	Car	1.04								
	Walk			1 (norm)						
	Cycle				1 (norm)					
	Public Transport					2.66 (significant larger than 1)				

T*able 4: Implicit Value of Time in MPM23 and the Norwegian Value of Time Study for trips under 50 km (Halse et al 2010)*

VoT (NOK/hour) (95%confidence intervals)	**Car**	**Train/ Comb. with train**	**Bus**	**Metro/tram**	**Comb. bus with metro/tram**	**Public Transport**
MPM23 (mode choice, revealed preference data, trips within Oslo/Akershus)						
Invehicle time	34.2 (10.4-57.8)	32.0 (20.2-43.8)	25.4 (19.1-31.7)	30.6 (21.7-39.5)	35.1 (24.6-45.5)	
Access/egress time		50.6 (40.6-60.5)	58.5 (47.5-69.4)	75.0 (58.8-91.2)	57.7 (39.9-75.5)	
Waiting time		57.6 (41.6-73.5)	32.2 (18.8-45.5)	33.1 (5.5-60.6)	21.0 (-4.2-46.2)	
Norwegian Value of Time Study (route choice, stated preference, national wide value for trips under 50 km but over 10 minutes, adjusted from 2009 to 2015 with real GDP growth)						
Invehicle time	86.4					57.6

The model includes a dummy variable for the season of the year. Clearly, walking and cycling are more attractive between April and September compared to the rest of the year.

An additional dummy variable for female respondents is included in the utility function for car passengers. From the estimated coefficient, we see that that woman have a significantly higher probability of being car passengers.

As mentioned above we included dummy variable for distance in the utility function for the train alternatives. Sign and relative size of these variables are as expected, i.e. the longer the trip the higher the probability to take train.

An additional dummy variable is one when the trip started and ended in the same zone of the network model the LoS-data is imported from. As expected are walking and cycling relatively more attractive for these type of trips. As mentioned in section 2, public transport is not available for these trips as there exists no LoS-data for zonal-internal trips from the network model.

The scale parameters for nest «car» is estimated at 1.04 (the value is not significant different from 1). Only a weak correlation in the utility of “car driver” and “car passenger” is therefore indicated. The parameter for nest “public transport” is 2.66 and highly significant different from 1 and indicating a high correlation among the alternatives in this nest.

Nest parameters have direct impact on simulated cross elasticities. As seen in Table A1 in the appendix cross elasticities in MPM23 are generally higher within the nest “public transport” indicating a higher substitution pattern between bus, train and metro/tram. We refer to Fearnley et al (2016) for a discussion about cross-elasticities as calculated by MPM23.

5. Spreadsheet model for policy analysis

The spreadsheet model MPM23 (Version 1.1) is structured in 13 standard Excel-spreadsheet, one for scenario definition and main results, 12 for results on submarkets and one for the internal calculations.
In the spreadsheet for scenario definition, the user can choose the geographic area the policy is implemented (default is the whole Oslo/Akershus area). Then she can define a certain policy scenarios by specifying percentage changes of LoS variables as well as changes in population share of observations having/being “free parking” and “satisfaction with public transport”. Changes in LoS are specified as percentages of the original values used for estimation. In the reference scenario, the values are usually kept at 100% while one or more LoS are varied for the policy scenario. With the chosen set up of MPM23 (Version 1.1), it is not possible to change values for choice alternative “combination with train” and “combination with bus and metro/tram”. Rather one specifies changes for LoS of train, bus and metro/tram and distribution weights specifying how LoS for the two combined alternatives are effected by the specified changes in LoS of the “main” travel modes.
For dummy variables “free parking” and “satisfaction with public transport”, the share in the reference scenario are hold at the corresponding share in the specified area, while share can be adjusted (between 0-100%) for the policy scenario. Figure 3 shows the layout of the spreadsheet for scenario specification. It shows a scenario specification where the ticket prices for train, bus and metro/tram within Oslo are set to 0% of the original values, meaning free public transportation for trip within Oslo (ticket prices for trip starting and/or ending in Akershus are kept at the original value).

The spreadsheet for internal calculations (not visible for the user by default), calls the values (percentages and shares) specified in the scenario definition spreadsheet and calculates choice probabilities for the reference and policy scenario. While applying percentage changes on the LoS variables in calculation is rather straightforward, a mechanism had to be developed that specifies which individually dummy variable for “free parking” and “satisfaction with public transport” change value from 0 to 1 (or from 1 to 0) given on the specified shares for the applied geographical area. The implemented solution is based on a random ranking of observations defining the order by which dummy variables shift their value. Obviously, when specifying a 100% share of “free parking” (“satisfaction”) all choice probabilities for observations in applied geographical area a calculated with a corresponding dummy variable set to value 1. The spreadsheet also aggregates results, for the whole market and for different segments/submarkets (by trip purposes, geographical zones, trip distance).

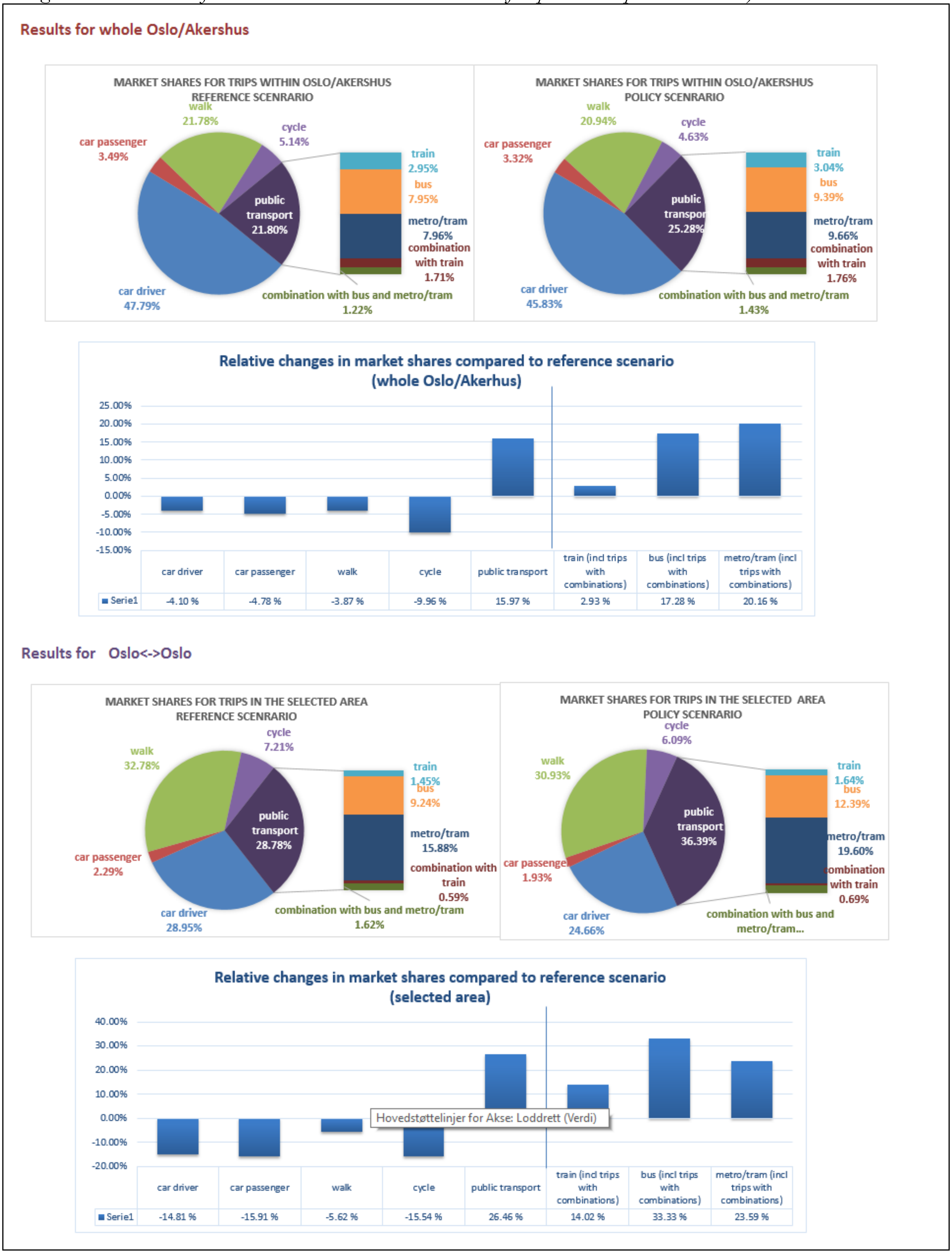
Results in forms of diagrams and tables are then presented in the remaining spreadsheet. The main results for the whole market and the area the policy is apply to, are given next to the cells where the scenario is specified (Figure 3). Figure 4 shows results for the case of free public transport for trips within Oslo. The first two panels show results for the whole area of Oslo/Akershus. The cake-diagrams show (absolute) market shares in both scenarios and the pillar-diagram shows the relative changes in market shares[13]. The second last two panels are corresponding results for the trips within Oslo. In the next section, results of this and similar policy specification around free public transport are presented and briefly discussed.

[13] For the pillar diagrams, the changes “combination with train” and “combination with bus and metro/tram” are included into tog, buss and metro/tram given the distributional weights specified for the policy scenario.

Figure 3. Screen shoot of spreadsheet for policy definition in MPM23 Version 1.1. (free public transport within Oslo)

	Geographic area of policy measure				
	Oslo<->Oslo				
		Referanse		**Policy scenario**	
Level of Service (LoS)		*% of orginal value at yesterdays trip*			
Car	**travel time**	100.00 %		100.00 %	
	travel cost (for fuel and toll)	100.00 %		100.00 %	
Train	**access/egress time**	100.00 %		100.00 %	
	waiting times	100.00 %		100.00 %	
	single ticket price	100.00 %		0.00 %	
	number of interchanges	100.00 %		100.00 %	
	invehicle time	100.00 %		100.00 %	
Bus	**access/egress time**	100.00 %		100.00 %	
	waiting times	100.00 %		100.00 %	
	single ticket price	100.00 %		0.00 %	
	number of interchanges	100.00 %		100.00 %	
	invehicle time	100.00 %		100.00 %	
Metro/tram	**access/egress time**	100.00 %		100.00 %	
	waiting times	100.00 %		100.00 %	
	single ticket price	100.00 %		0.00 %	
	number of interchanges	100.00 %		100.00 %	
	invehicle time	100.00 %		100.00 %	
		% of travel population in Ruter's MIS			Ir
Situation					cl
	parking free of charge	40.18 %		uforandret	
Statisfaction					
	satisfied with public transport	81.26 %		uforandret	
	(indepedent of LoS-variables)				
Shares within "combination with train"			100 %	Distribute 100	
	train		50 %		
	bus		25 %		
	metro/tram		25 %		
Shares within "combinations bus and metro/tram			100 %	Distribute 100	
	bus		50 %		
	metro/tram		50 %		

Figure 4. Presentation of main results in MPM23 Version 1.1 (free public transport within Oslo)



6. Case study of free public transport services

Free public transport services is a policy instrument sometimes suggested as a mean to reduce car ridership and its attached emissions. Recently a study by Aas et al (2015) has investigated free public

transport as a short-term measure to reduce NO_2-emissions in Oslo/Akershus. Using RTM (for effects on newly generated traffic) and MPM23 (for effects on market shares), they concluded that free public transport alone is not sufficient for the demanded NO_2-emissions reductions.
In the remainder of this section, we illustrate how the effects of free public transport vary between different segments of the markets. As mentioned in section 5, trips undertaken with period tickets are specified in the model as having no marginal cost. The percent changes applied in MPM23 are therefore only related to single tickets, which suggest interpreting the following results as short-term effects.
Table A2 in the appendix shows predicted market shares and changes in market shares related to the reference scenario for a policy where all public transport trips within Oslo/Akershus are free of charge (this differs from the specification in section 6 where only trips within Oslo are free of charge). The market share of public transport for the whole market increases by 8.4% percent points to a new market share of 30.2%, while car driver share drops by 6.1 percent point to a market share of 41.7%. Walk (cycle) lose 1.0 (0.8) percent point and have a share of 20.8% (4.4%) in the new market situation. Within different public transport forms, bus has the highest absolute (and relative) change, going from 8% to 12%, followed by metro/tram going from 7.9% to 9.9% and train going from 3% to 4.1%.[14]
Looking only at trips within Oslo (results corresponding to the last two panels in Figure 3), one can see that the absolute share of people sifting from car to public transport is with 4.3% lower (compared to 6.1% for the whole market). However, the market share for car in the reference scenario is much lower for trips within Oslo such that the relative change is actually greater.
The highest effect of the policy is found for trips between Oslo and Akershus, here the market share of public transport increase by 16.9% (going from 37.2 to 50.1%). Many trips between Oslo and Akershus are longer distance commuting trips. Looking at market segmentation results shown in Table A1 we see a consistent picture in that absolute changes are greatest for commuting (and trips within working hours) and for longer-distance trips. In general, one can recognise an intuitive picture that absolute changes in market shares are rather low when market shares in the reference scenario are low (e.g. car driver for school trips) or high (e.g. walking for trips between 0.2km) while changes in market shares are generally higher when market shares are more evenly distributed in the reference scenario. Note that this directly connected to the (intuitive) S-shaped probability function of the logit model.
Table A3 shows a corresponding table for a policy where only train services within Oslo/Akershus are free of charge (ticket price for bus and metro/tram is hold at current level). Not surprisingly, the effect of public transport ridership is lower (predicted markets shares for all submarkets are lower than in Table A2). However, market shares for train are greater in all submarkets compared to the previous policy scenario. The reason for this is obviously that train is gaining market shares from buss and metro/tram. As it was already indicated by the cross-elasticities in appendix A2, there seems to be a relatively strong degree of cannibalism within the different form of public transport.
Table A4 shows predicted marked shares for the whole Oslo/Akershus, but varies the geographical area and the transport modes the free-of-charge service is applied to. The first two policy specification, indexed 1 and 2, correspond to the situation of the first result line in Table A2 and A3 respectively; results in the cake-diagrams from the top panel in Figure 3 corresponds to the policy indexed 5 in Table A3. One of the insights gained from Table A4 is that making bus free of charge generates most public transport shares (compared to making train or metro/tram free of charge). This applies for all analysed geographical areas. A reason for that is that buss is in competition with both walk/cycle (for short distance trips) and with car (mainly longer distance trips). The internal ranking between train and metro/tram depends on the geographical area the policy is applied to. Free train services have a higher overall effect in the trips between Oslo and Akershus and the

[14] For completeness, «combination with train increases by 2.9 percent points to a share of 2.6% while “combination with buss and metro/tram increases by 0.5% to a market share of 1.7%. The market share of car passengers decreases by 0.6 percent points and is at 2.9% in the policy scenario.

internal Akershus trips, while for trips within Oslo (typically shorter trips) free metro/tram has the greater effect on public transport ridership.

7. Conclusion and possible future mode l development

We presented a stand-alone travel mode choice model for short distance trips in the Oslo area. The implementation in Excel, offering an easy accessible and user-friendly user interface, was rather straightforward despite the applied nested logit structure and the high number of choice alternatives (9), model parameters (120) and observations (close to 15,000). A simple and intuitive set up for scenario definitions allows testing a range of policy scenarios. Sample enumeration was chosen as a method for market share predictions; results are available within 1-2 seconds after scenario specification. Market shares are segmented into sub-markets illustrating the heterogeneity in markets shares in the reference scenario and heterogeneity of effects of policies.

The parameters of the model are estimated on revealed preference survey data. In the implemented model, all parameters had expected/reasonable sign, making the authors confident that the model predicts the right direction of effects. However, the implicit value of time indicated that the relative impact of travel time attributes is somewhat underestimated by the model. Estimation of future model version should investigate this more deeply and eventually improve the model in that respect.

A case study of free public transport showed largely reasonable results, also after segmenting results into submarkets. Interestingly, the degree of substitution within different public transport modes (train, bus and metro/tram) was found much stronger than towards other type of transport (car, walk and cycle). This is a new insight gained from this model as the traditional (short-distance) travel demand models in Norway handle public transport as a common alternative. It is likely that a large extent of these results is in direct connection to the applied nested structure and the high estimated scale parameter for nest “public transport”. The nesting structure should be tested again (and if needed changed) in future model versions.

Sample enumeration as a method of prediction is most reliable when a big and representative sample is at hand. For the whole market (and the coarser segmented submarket), the authors are confident that the available sample size is sufficient for the purpose of simple policy analysis and testing. Detailed analysis, e.g. on single bus lines – is, however, not recommended. In order to facilitate such high-resolution analyses one might apply the behavioral model (the disaggregated logit model) to a synthetic population allowing simulating individual choices “one-by-one”. Given the synthetic population being geographically representative, this would likely by the most rigorous and precise way of prediction market shares.

The presented model does not predict newly generated transport, which in the real world is likely to result from policy measures that improve Level-of-service variables. To improve the model, while keeping the model still tractable in spreadsheets, an approach could be to predict newly generated traffic from changes in log-sum measures (which are easily calculated in nested logit models).

In section 4, we described the simplified modelling of the variable “satisfaction with public transport”. Future research should look into improving the modelling of this variable, e.g. by the use of latent variable models or by the use of structural equation models where satisfactions is an endogenous part of the model dependent on the specified level of LoS. However, this would surely complicate the model. It would also make the use of sample enumeration more demanding and possibly not feasible in simple spreadsheets.

Finally, we want to point out the model would gain precision in LoS-variables when the survey would include information about departure time of trips. With that information it would also be possible the segment results by time of the day. This might further help to explain the heterogeneity in market shares in the Oslo Area.

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Appendix

Table A1: Calculated (cross-) elasticities (1% arc-elasticities) in MPM23

Changes for car

	Car driver	Car passenger	Walk	Cycle	ic Transport	Train (including combinations)	Bus (including combinations)	Tram/metro (including combinatio
Travel time	**-0.05**	-0.10	0.02	0.08	0.09	0.13	0.10	0.06
Travel cost	**-0.08**	-0.15	0.03	0.11	0.14	0.25	0.15	0.09

Same changes for train, buss and train/metro

	Car driver	Car passenger	Walk	Cycle	ic Transport	Train (including combinations)	Bus (including combinations)	Tram/metro (including combinatio
access times	0.08	0.18	0.05	0.19	**-0.29**	**-0.42**	**-0.13**	**-0.41**
waiting times	0.02	0.06	0.01	0.04	**-0.08**	**-0.22**	**-0.07**	**-0.03**
single ticket price	0.08	0.14	0.04	0.13	**-0.26**	**-0.24**	**-0.31**	**-0.21**
# boardings	0.05	0.11	0.03	0.12	**-0.18**	**0.15**	**-0.38**	**-0.12**
invehicle time	0.05	0.11	0.01	0.09	**-0.16**	**-0.07**	**-0.20**	**-0.15**

Changes only for train

	Car driver	Car passenger	Walk	Cycle	ic Transport	Train (including combinations)	Bus (including combinations)	Tram/metro (including combinatio
access times	0.02	0.04	0.00	0.01	-0.05	**-0.77**	0.15	0.06
waiting times	0.01	0.02	0.00	0.01	-0.02	**-0.30**	0.06	0.01
single ticket price	0.02	0.03	0.00	0.01	-0.04	**-0.39**	0.05	0.01
# boardings	0.00	0.01	0.00	0.00	-0.01	**-0.15**	0.03	0.01
invehicle time	0.01	0.02	0.00	0.01	-0.03	**-0.35**	0.07	0.01

Changes only for bus

	Car driver	Car passenger	Walk	Cycle	ic Transport	Train (including combinations)	Bus (including combinations)	Tram/metro (including combinatio
access times	0.03	0.09	0.02	0.08	-0.13	0.25	**-0.66**	0.25
waiting times	0.01	0.03	0.00	0.02	-0.04	0.08	**-0.18**	0.06
single ticket price	0.04	0.07	0.02	0.07	-0.13	0.12	**-0.47**	0.11
# boardings	0.03	0.07	0.02	0.07	-0.10	0.24	**-0.58**	0.23
invehicle time	0.02	0.06	0.01	0.04	-0.07	0.22	**-0.42**	0.15

Changes only for tram/metro

	Car driver	Car passenger	Walk	Cycle	ic Transport	Train (including combinations)	Bus (including combinations)	Tram/metro (including combinatio
access times	0.03	0.05	0.03	0.10	-0.12	0.11	0.38	**-0.72**
waiting times	0.01	0.01	0.00	0.01	-0.02	0.01	0.05	**-0.11**
single ticket price	0.02	0.03	0.02	0.06	-0.09	0.02	0.10	**-0.32**
# boardings	0.02	0.03	0.01	0.05	-0.06	0.06	0.17	**-0.36**
invehicle time	0.01	0.03	0.01	0.04	-0.05	0.06	0.15	**-0.30**

Tabell A1 Market shares (and changes in market shares) in submarkets for policy for free public transport services in whole Oslo/Akershus

Policy index	Market share in submarked as result of free public transportation	Car driver		Car passenger		Walk		Cycle		Public transport		Train		Bus		Metro/Tram		Comb. with train		Comb. With buss and Metro/Tram	
		Market share	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*
	Segmented after geografical relation																				
1	**All trips within Oslo/Akershus**	41.7 %	-6.1 %	2.9 %	-0.6 %	20.8 %	-1.0 %	4.4 %	-0.8 %	30.2 %	8.4 %	4.1 %	1.1 %	12.0 %	4.0 %	9.9 %	2.0 %	2.6 %	0.9 %	1.7 %	0.5 %
1	**trips within Oslo**	24.7 %	-4.3 %	1.9 %	-0.4 %	30.9 %	-1.9 %	6.1 %	-1.1 %	36.4 %	7.6 %	1.6 %	0.1 %	12.4 %	3.2 %	19.6 %	3.7 %	0.7 %	0.1 %	2.1 %	0.5 %
1	**trips between Oslo and Akershus**	40.4 %	-14.7 %	2.7 %	-1.1 %	0.8 %	-0.2 %	2.0 %	-1.0 %	54.2 %	16.9 %	14.5 %	3.6 %	20.0 %	7.4 %	5.2 %	1.3 %	10.4 %	3.3 %	4.2 %	1.5 %
1	**trips within Akershus**	63.1 %	-4.4 %	4.2 %	-0.6 %	17.4 %	-0.3 %	3.3 %	-0.3 %	12.0 %	5.6 %	2.4 %	1.2 %	7.9 %	3.6 %	0.2 %	0.1 %	1.4 %	0.7 %	0.2 %	0.1 %
	Segmented after trip purpose																				
1	**commuting trips**	34.4 %	-9.5 %	1.8 %	-0.4 %	8.3 %	-1.1 %	5.8 %	-1.5 %	49.7 %	12.5 %	7.8 %	1.7 %	18.9 %	6.0 %	14.8 %	2.5 %	5.2 %	1.5 %	3.1 %	0.8 %
1	**trips to school/university**	5.9 %	-1.8 %	3.9 %	-0.9 %	11.6 %	-1.2 %	6.9 %	-1.4 %	71.8 %	5.2 %	7.8 %	0.8 %	27.1 %	2.5 %	26.7 %	1.5 %	6.0 %	0.4 %	4.2 %	0.0 %
1	**trips within working hours**	37.8 %	-13.0 %	4.1 %	-1.3 %	8.5 %	-0.8 %	2.5 %	-0.7 %	47.1 %	15.8 %	5.7 %	2.3 %	17.1 %	6.6 %	17.6 %	4.0 %	3.9 %	1.7 %	2.7 %	1.1 %
1	**grocery shopping**	50.0 %	-3.9 %	3.1 %	-0.4 %	26.3 %	-0.8 %	3.6 %	-0.4 %	16.9 %	5.5 %	2.1 %	0.7 %	7.5 %	2.8 %	5.7 %	1.4 %	1.0 %	0.4 %	0.7 %	0.2 %
1	**delivering/picking up**	70.3 %	-3.0 %	1.0 %	-0.1 %	18.1 %	-0.3 %	2.7 %	-0.2 %	7.9 %	3.5 %	0.8 %	0.5 %	3.7 %	1.6 %	2.4 %	0.8 %	0.6 %	0.3 %	0.5 %	0.2 %
1	**other leisure trips**	34.1 %	-5.8 %	4.3 %	-1.0 %	29.7 %	-1.4 %	4.2 %	-0.7 %	27.7 %	8.8 %	3.2 %	1.2 %	11.1 %	4.0 %	9.9 %	2.2 %	1.9 %	0.9 %	1.5 %	0.5 %
	Segmented after trip distance																				
1	**0-2km**	31.8 %	-0.4 %	2.0 %	0.0 %	56.3 %	-0.7 %	5.4 %	-0.1 %	4.5 %	1.3 %	0.0 %	0.0 %	2.2 %	0.7 %	2.3 %	0.6 %	0.0 %	0.0 %	0.0 %	0.0 %
1	**2-5km**	42.7 %	-4.4 %	3.1 %	-0.5 %	14.9 %	-2.7 %	5.9 %	-1.3 %	33.5 %	8.9 %	0.7 %	0.2 %	15.8 %	5.0 %	16.2 %	3.4 %	0.1 %	0.0 %	0.7 %	0.2 %
1	**5-10km**	46.4 %	-8.3 %	3.4 %	-0.8 %	1.6 %	-0.5 %	4.7 %	-1.4 %	43.9 %	11.0 %	2.9 %	0.9 %	17.8 %	5.6 %	19.4 %	3.5 %	0.4 %	0.1 %	3.4 %	0.8 %
1	**10-25km**	48.0 %	-11.0 %	3.3 %	-1.1 %	0.0 %	0.0 %	1.9 %	-0.8 %	46.9 %	12.9 %	11.2 %	2.5 %	17.0 %	5.9 %	7.3 %	1.2 %	7.1 %	2.0 %	4.3 %	1.3 %
1	**over 25 km**	50.8 %	-16.2 %	3.4 %	-1.4 %	0.0 %	0.0 %	0.1 %	-0.1 %	45.7 %	17.7 %	17.8 %	6.1 %	10.7 %	5.1 %	0.0 %	0.0 %	15.9 %	6.0 %	1.3 %	0.6 %

Tabell A2 Market shares (and changes in market shares) in submarkets for policy of free train services in whole Oslo/Akershus area

		car driver		car pasasenger		Walk		Cycle		Public transport		Train		Bus		Metro/Tram		Comb. with		and Metro/Tram	
Policy i	Market share in submarked as result of free train service	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*
	Segmented after geografical relation																				
2	**All trips within Oslo/Akershus**	46.0%	-1.8%	3.3%	-0.2%	21.7%	0.0%	5.0%	-0.1%	23.9%	2.1%	5.5%	2.6%	7.5%	-0.5%	7.8%	-0.2%	2.0%	0.2%	1.2%	0.0%
2	**trips within Oslo**	28.6%	-0.4%	2.3%	0.0%	32.7%	-0.1%	7.1%	-0.1%	29.3%	0.5%	2.4%	1.0%	9.1%	-0.2%	15.5%	-0.4%	0.7%	0.1%	1.6%	0.0%
2	**trips between Oslo and Akershus**	48.9%	-6.1%	3.2%	-0.6%	0.9%	0.0%	2.6%	-0.3%	44.3%	7.1%	18.8%	7.8%	11.2%	-1.5%	3.8%	-0.2%	8.1%	1.1%	2.5%	-0.2%
2	**trips within Akershus**	65.9%	-1.6%	4.6%	-0.2%	17.6%	-0.1%	3.5%	-0.1%	8.4%	2.1%	3.5%	2.2%	3.9%	-0.4%	0.1%	0.0%	0.8%	0.1%	0.1%	0.0%
	Segmented after trip purpose																				
2	**commuting trips**	41.0%	-2.9%	2.1%	-0.1%	9.3%	0.0%	7.1%	-0.2%	40.6%	3.3%	10.0%	3.9%	12.1%	-0.7%	12.1%	-0.2%	4.1%	0.5%	2.2%	-0.1%
2	**trips to school/university**	6.9%	-0.7%	4.3%	-0.5%	12.6%	-0.1%	7.8%	-0.4%	68.3%	1.7%	10.0%	2.9%	23.6%	-1.0%	24.9%	-0.3%	5.7%	0.1%	4.2%	0.0%
2	**trips within working hours**	46.8%	-4.0%	5.0%	-0.5%	9.2%	0.0%	3.1%	-0.1%	35.9%	4.6%	9.3%	5.9%	9.2%	-1.3%	12.9%	-0.7%	3.1%	0.9%	1.4%	-0.2%
2	**grocery shopping**	53.0%	-1.0%	3.4%	-0.1%	27.1%	0.0%	3.9%	-0.1%	12.6%	1.2%	2.9%	1.5%	4.4%	-0.2%	4.2%	-0.1%	0.7%	0.1%	0.4%	0.0%
2	**delivering/picking up**	72.5%	-0.8%	1.0%	0.0%	18.4%	0.0%	2.8%	0.0%	5.3%	0.9%	1.3%	0.9%	2.0%	-0.1%	1.5%	-0.1%	0.3%	0.1%	0.2%	0.0%
2	**other leisure trips**	38.2%	-1.7%	4.9%	-0.3%	31.0%	-0.1%	4.8%	-0.1%	21.1%	2.2%	4.7%	2.7%	6.6%	-0.4%	7.5%	-0.2%	1.3%	0.2%	1.0%	0.0%
	Segmented after trip distance																				
2	**0-2km**	32.2%	0.0%	2.1%	0.0%	57.0%	0.0%	5.5%	0.0%	3.3%	0.0%	0.0%	0.0%	1.5%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%
2	**2-5km**	46.9%	-0.3%	3.5%	0.0%	17.5%	-0.1%	7.1%	-0.1%	25.1%	0.5%	1.4%	0.9%	10.5%	-0.2%	12.6%	-0.2%	0.0%	0.0%	0.5%	0.0%
2	**5-10km**	53.2%	-1.4%	4.1%	-0.2%	2.0%	-0.1%	5.9%	-0.3%	34.8%	2.0%	5.3%	3.3%	11.4%	-0.8%	15.3%	-0.6%	0.4%	0.1%	2.5%	-0.1%
2	**10-25km**	54.8%	-4.1%	3.9%	-0.5%	0.0%	0.0%	2.4%	-0.3%	38.9%	4.9%	14.4%	5.7%	9.8%	-1.3%	6.0%	-0.1%	5.8%	0.8%	2.9%	-0.2%
2	**over 25 km**	57.8%	-9.3%	4.0%	-0.8%	0.0%	0.0%	0.1%	0.0%	38.1%	10.1%	21.1%	9.4%	5.2%	-0.4%	0.0%	0.0%	11.0%	1.2%	0.7%	0.0%

Tabell A3 Market shares (and changes in market shares) in for the whole Oslo/Akershus area for different policies

Market shares for whole market (Oslo Akerhus)			Car driver		Car passenger		Walk		Cycle		Public transport		Train		Bus		Metro/Tram		Comb. with train		Comb. With buss and Metro/Tram	
Policy index	Applied geografical relation	Applied public transport mode	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*	*Market share*	*Change (percent points)*
1	All trips within Oslo/Akershus	all	41.7 %	-6.1 %	2.9 %	-0.6 %	20.8 %	-1.0 %	4.4 %	-0.8 %	30.2 %	8.4 %	4.1 %	1.1 %	12.0 %	4.0 %	9.9 %	2.0 %	2.6 %	0.9 %	1.7 %	0.5 %
2		only train	46.0 %	-1.8 %	3.3 %	-0.2 %	21.7 %	0.0 %	5.0 %	-0.1 %	23.9 %	2.1 %	5.5 %	2.6 %	7.5 %	-0.5 %	7.8 %	-0.2 %	2.0 %	0.2 %	1.2 %	0.0 %
3		only buss	43.6 %	-4.2 %	3.0 %	-0.4 %	21.1 %	-0.7 %	4.6 %	-0.6 %	27.7 %	5.9 %	2.5 %	-0.4 %	15.5 %	7.6 %	6.8 %	-1.2 %	1.6 %	-0.1 %	1.3 %	0.0 %
4		only tram/metro	45.9 %	-1.8 %	3.3 %	-0.2 %	21.2 %	-0.6 %	4.7 %	-0.4 %	24.8 %	3.0 %	2.8 %	-0.2 %	7.2 %	-0.8 %	11.5 %	3.5 %	2.0 %	0.3 %	1.4 %	0.2 %
5	Trips within Oslo	all	45.8 %	-2.0 %	3.3 %	-0.2 %	20.9 %	-0.8 %	4.6 %	-0.5 %	25.3 %	3.5 %	3.0 %	0.1 %	9.4 %	1.4 %	9.7 %	1.7 %	1.8 %	0.0 %	1.4 %	0.2 %
6		only train	47.6 %	-0.2 %	3.5 %	0.0 %	21.8 %	0.0 %	5.1 %	0.0 %	22.0 %	0.2 %	3.4 %	0.5 %	7.9 %	-0.1 %	7.8 %	-0.2 %	1.7 %	0.0 %	1.2 %	0.0 %
7		only buss	46.6 %	-1.2 %	3.4 %	-0.1 %	21.2 %	-0.6 %	4.8 %	-0.3 %	24.0 %	2.3 %	2.9 %	-0.1 %	11.3 %	3.3 %	6.9 %	-1.0 %	1.7 %	0.0 %	1.3 %	0.0 %
8		only tram/metro	46.5 %	-1.3 %	3.4 %	-0.1 %	21.2 %	-0.6 %	4.8 %	-0.3 %	24.1 %	2.3 %	2.9 %	-0.1 %	7.4 %	-0.5 %	10.8 %	2.9 %	1.7 %	0.0 %	1.2 %	0.0 %
9	Trips between Oslo and Akerhus	all	45.3 %	-2.5 %	3.3 %	-0.2 %	21.8 %	0.0 %	5.0 %	-0.2 %	24.6 %	2.8 %	3.6 %	0.6 %	9.2 %	1.2 %	8.2 %	0.2 %	2.3 %	0.6 %	1.5 %	0.2 %
10		only train	46.8 %	-1.0 %	3.4 %	-0.1 %	21.8 %	0.0 %	5.1 %	-0.1 %	23.0 %	1.2 %	4.3 %	1.3 %	7.7 %	-0.2 %	7.9 %	0.0 %	1.9 %	0.2 %	1.2 %	0.0 %
11		only buss	46.1 %	-1.7 %	3.3 %	-0.2 %	21.8 %	0.0 %	5.0 %	-0.1 %	23.8 %	2.0 %	2.7 %	-0.3 %	10.5 %	2.5 %	7.8 %	-0.1 %	1.6 %	-0.1 %	1.2 %	0.0 %
12		only tram/metro	47.3 %	-0.5 %	3.4 %	0.0 %	21.8 %	0.0 %	5.1 %	-0.1 %	22.4 %	0.6 %	2.9 %	-0.1 %	7.8 %	-0.2 %	8.5 %	0.5 %	1.9 %	0.2 %	1.4 %	0.2 %
13	Trips within Akershus	all	46.1 %	-1.6 %	3.3 %	-0.2 %	21.7 %	-0.1 %	5.0 %	-0.1 %	23.9 %	2.1 %	3.4 %	0.4 %	9.3 %	1.3 %	8.0 %	0.0 %	2.0 %	0.3 %	1.3 %	0.0 %
14		only train	47.2 %	-0.6 %	3.4 %	-0.1 %	21.8 %	0.0 %	5.1 %	0.0 %	22.5 %	0.7 %	3.8 %	0.8 %	7.8 %	-0.1 %	8.0 %	0.0 %	1.7 %	0.0 %	1.2 %	0.0 %
15		only buss	46.6 %	-1.2 %	3.3 %	-0.2 %	21.7 %	-0.1 %	5.0 %	-0.1 %	23.4 %	1.6 %	2.9 %	-0.1 %	9.7 %	1.7 %	8.0 %	0.0 %	1.7 %	0.0 %	1.2 %	0.0 %
16		only tram/metro	47.7 %	-0.1 %	3.5 %	0.0 %	21.8 %	0.0 %	5.1 %	0.0 %	21.9 %	0.1 %	2.9 %	0.0 %	7.9 %	0.0 %	8.0 %	0.1 %	1.8 %	0.1 %	1.2 %	0.0 %