Institute of Transport Economics
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Summary

Further development of the market potential model for Oslo and Akershus (MPM23 V2.0)

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On behalf of Ruter AS, TØI has further developed the travel mode choice model MPM23. The greatest methodological improvement is that the purchase of ticket type (periodic or single ticket) is predicted with the choice of transport mode in a joint choice model. Another improvement is a better segmentation of geographical zones and travel modes. There is now a distinction between tram and subway, and Park & Ride is an independent choice alternative.

Purpose of the project

According to the agreement with Ruter, the further development of MPM23 includes an estimated model based on new data from Router MIS (incl. December 2016), with the following methodical improvements:

- Period card: Own modelling of the purchase of period cards in joint estimation model
- Rush/non-rush: Testing of different parameters in rush/non-rush and increased functionality in the model so that results can be segmented in rush and non-rush
- An improved categorisation for geographical zones

Data

Version 2 of MPM23 is based on reported trips from September 2014 to December 2016 from travel survey Ruter MIS.

The model includes 47762 trips within Oslo/Akershus, carried out by one or several of the following travel modes: car (driver or passenger), public transport (excluding boat / ferry and airport train), walk or bicycle. Unlike RTM, single trips (not round trips) are modelled in MPM23. The geographical relations in MPM23 are not directional.

Observations are weighted in order to be representative for a full year and to offset some skewedness in the geographical distribution of interviews.

With the same principle as in Version 1, the main travel mode for each trip is defined based on reported travel modes of the first two legs of each trip. New in Version 2.0 is that:

1. Tram and subway are separated alternatives

2. The combination between car and train ("park and ride") is an own choice alternative.

The same accessibility criteria are used as in Version 1. The new option Park & Ride is defined as available when "train" or "combination of train" is available. You do not need a driver's license to choose Park & Ride since the Park & Ride can also be carried out as car passenger.

TØI has received a comprehensive data delivery of Level-of-Service from Ruter. All data came in matrix form with a fine zonal segmementation (grunnkrets) and divided into

"morning rush" and "non-rush". We have transported "morning rush" to the "afternoon rush" in the opposite direction and have linked LoS data to single observations in Ruter MIS based on the reported clock-time in MIS. For observations without information about clock time (before autumn 2015) we have developed a method that guesses the time period. This method has been improved compared to Version 1.

In the model itself, the results are segmented by zonal relations. In version 2, 12 different zones are used, thus the model operates with 78 different zonal relations.

Model Development

Besides, the finer zonal division and a better breakdown in rush and non-rush, the greatest methodological development is the handling of purchase of seasonal cards and single tickets. For each individual observation, the relevant prices are calculated according to the discount scheme. The price for period cards is then converted to average price per single trip based on questions in Ruter MIS about how often people travel with public transport. The method involves some random draws to allocate the number of journeys by public transport evenly over the observation. Figure S1 shows trade-off between single-ticket and average price per trip given periodic cards. It is mainly people who report that they travel 2-3 days a week (green observations in Figure S1) who will switch between single and period tickets.

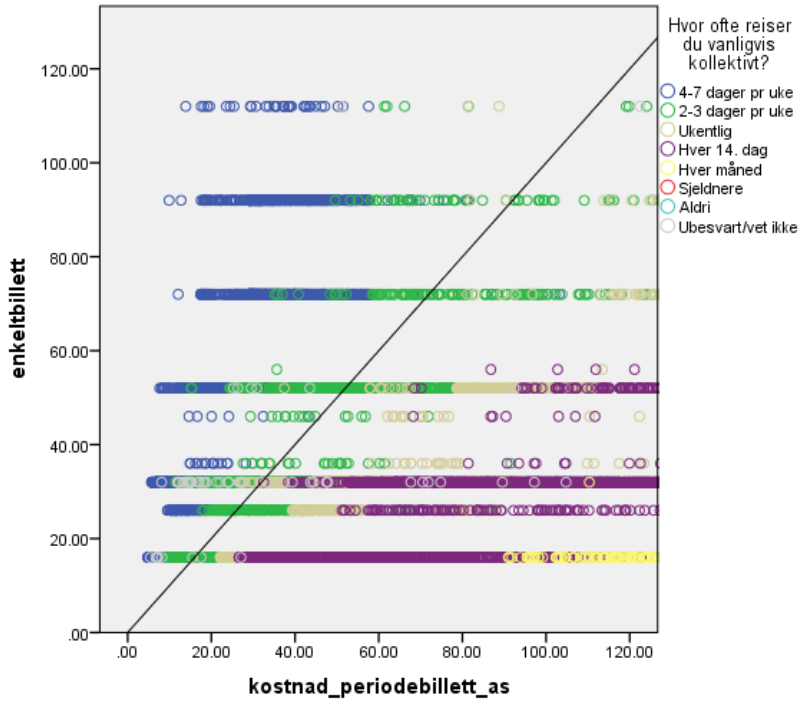

Figure S1: Costs (in NOK) for single tickets (y-axis) cost ***per trip for seasonal cards (x-axis)*** *in MPM23, zoomed and with 45 degree line*

As in the previous version, MPM23 Version 2 is a nested logit model. The choice set consists of a maximum of 18 choice alternatives, of which 14 of these of different forms within public transport, with either a seasonal cards or single ticket. The other 4 options are car driver, car passenger, cycling and walking, which kind of ticket is naturally not included in the utility function. Choice alternatives are hierarchically structured and decision makers

can be interpreted to first choice the type of ticket (seasonal or single ticket) and then the form of public transportation.

MPM23 calculates choice probabilities for each alternative for all single trips in our sample selection (N = 47762). For alternatives defined as "unavailable", the probability of probability is set to 0%. For each trip, the probabilities sum up to 100%. Aggregation of choice alternatives yields predicted market shares.

Estimation model

Similar to version 1, the explanatory variables in MPM23 v2.0 can be dived into:

- Alternative specific constants
- LoS variables
- Travel costs (for car: sum of toll and fuel costs; for public transport: ticket price per single ride)
- Invehicle time
- Access/egress times (sum)
- Waiting time
- Number of boardings
- Travel distance (for walking)
- Dummy Variables for zonal relations
- Dummy variables for different trip purposes
- Dummy variables for satisfaction with public transport
- Dummy variable for free parking
- Various other dummy variables (gender, season, distance)

New in Version 2 is:

- For cycling: travel distance is replaced by cycling time
- The utility function for cycle includes the net gradient of the trip
- Parking spaces for Park & Ride (dummy and number of parking places if greater than 0)
- Dummy variable if car driver is an available alternative is included in the utility function of Park & Ride
- The parameters for boarding time are segmented into bus and other public transport (we measure thereby the so-called rail factor)
- Invehicle time (for public transport and car) and waiting time (public transport) are split up in rush and non-rush. Separated parameters are estimated
- The LoS variables to access and egress time are transformed with the square root
- Dummy variables for satisfaction and travel purposes are divided into public transport alternatives with seasonal cards and single ticket

We have tested many different model versions. The final models have expected signs for all coefficients and good explanatory power. As in version 1, we estimate relatively low implicit Values of Time (the ratio of coefficients of invehicle time and travel cost). Within the project framework, we did not succeed in getting these at a higher level without having at least one other coefficient switch to an unexpected signs.

As an alternative model, we have specified a model (model 2) where we have locked the relationship between the coefficient for travel costs and for different invehicle times, so that the implicate Value of Time corresponds to the level in the handbook for cost-benefit analyses of The Norwegian Rail Administration.

Table S1 reports the implicit value of time for Model 1 and Model 2.

Table S1: Implicit value of time in the two models

Value of time (NOK/h)	Model 1	Model 2
	Estimated	Adjusted to "official" level*
Invehicle time		
Car-rush	33.8	146.7
Car-non rush	10.9	47.4
PT on rails -rush	30.4	82.2
PT on rails -non rush	19.2	51.9
Bus-rush	34.4	92.8
Bus-non rush	22.7	61.3
Other value of time measures (estimated in both models)		
Cycling	105.4	201.7
Waiting time-rush	58.3	169.1
Waiting time-non rush	81.0	138.8
Access/egress time at 5 minutes	86.5	188.2
Access/egress time at 15 minutes	49.9	108.7
Access/egress time at 30 minutes	35.3	76.9

* is calculated as the weighted average of (price-adjusted) value of time for various trip purposes. Note that the coefficients (and thus the implicit value of time) are not segmented for travel purposes in MPM23.

Table S2 rapports simulated own- and cross-elasticities for model 2 in the rush-periods.

Table S2: Own- and cross-elasticities i rush-periods in Oslo/Akershus (1% arc-elasticity); Model 2 ("official" value of time)

Travel mode	Altered alternative	Car (driver /pass.)	Walk	Cycling	Public transport (comb.)	Train (incl P&R)	Buss	Subway	Tram
Car	travel time	-0.18	0.06	0.17	0.21	0.36	0.19	0.15	0.14
	fuel price	-0.04	0.01	0.03	0.05	0.11	0.05	0.03	0.03
	toll	-0.02	0.01	0.02	0.02	0.04	0.02	0.02	0.02
Public transport combined	access/egress	0.06	0.05	0.15	-0.16	-0.05	-0.17	-0.22	-0.16
	waiting time	0.05	0.03	0.09	-0.13	-0.13	-0.17	-0.07	-0.12
	single ticket	0.03	0.02	0.05	-0.08	-0.08	-0.10	-0.05	-0.07
	period card	0.06	0.05	0.11	-0.15	-0.15	-0.16	-0.13	-0.17
	boardings	0.02	0.01	0.03	-0.04	-0.02	-0.07	-0.03	-0.05
	invehicle time	0.08	0.03	0.13	-0.17	0.00	-0.32	-0.08	-0.20
train	access/egress	0.01	0.00	0.01	-0.02	-0.25	0.05	0.02	0.02
	waiting time	0.02	0.00	0.01	-0.03	-0.29	0.05	0.02	0.02
	single ticket	0.01	0.00	0.00	-0.02	-0.12	0.01	0.00	0.00
	period card	0.02	0.00	0.01	-0.03	-0.33	0.06	0.03	0.03
	boardings	0.00	0.00	0.00	-0.01	-0.07	0.01	0.01	0.00
	invehicle time	0.02	0.00	0.01	-0.03	-0.36	0.07	0.03	0.02
	parking places for P&R	0.00	0.00	0.00	0.01	0.10	-0.02	-0.01	-0.01
Bus	access/egress	0.02	0.02	0.06	-0.07	0.12	-0.34	0.11	0.08
	waiting time	0.02	0.02	0.04	-0.06	0.12	-0.28	0.07	0.04
	single ticket	0.01	0.01	0.02	-0.04	0.03	-0.13	0.02	0.01
	period card	0.02	0.03	0.05	-0.06	0.11	-0.30	0.07	0.06
	boardings	0.01	0.01	0.02	-0.02	0.04	-0.10	0.03	0.02
	invehicle time	0.04	0.02	0.06	-0.08	0.26	-0.47	0.14	0.09
Subway	access/egress	0.02	0.02	0.05	-0.05	0.06	0.10	-0.38	0.06
	waiting time	0.01	0.01	0.02	-0.03	0.03	0.04	-0.17	0.00
	single ticket	0.01	0.01	0.01	-0.02	0.01	0.01	-0.08	0.00
	period card	0.01	0.01	0.04	-0.04	0.04	0.06	-0.24	0.02
	boardings	0.00	0.00	0.01	-0.01	0.01	0.02	-0.06	0.00
	invehicle time	0.02	0.01	0.04	-0.04	0.07	0.06	-0.26	0.00
Tram	access/egress	0.01	0.01	0.02	-0.02	0.02	0.03	0.02	-0.31
	waiting time	0.01	0.01	0.01	-0.02	0.02	0.01	0.01	-0.19
	single ticket	0.00	0.01	0.01	-0.01	0.00	0.00	0.00	-0.09
	period card	0.01	0.01	0.02	-0.02	0.02	0.02	0.01	-0.28
	boardings	0.00	0.00	0.01	-0.01	0.01	0.01	0.00	-0.08
	invehicle time	0.01	0.01	0.02	-0.02	0.04	0.02	0.01	-0.31

Implementation

Like the first version, the second version of MPM23 is implemented in standard Excel spreadsheets. The spreadsheets are comprehensive and contain over 13.5 million equations.

Policy scenarios are defined as in version 1 as percent points of original input (100% means unchanged input).

New in version 2.0 is

- Users can switch between the parameters from Model 1 and Model 2. This allows you to test the demand effect given different levels of Value of Time (related to invehicle time)
- Users can change the applied weights. It is recommended to use the standard weights to get the analysis based on a more representative sample.
- Changes can be specified for fuel costs and toll separately
- For some attributes, you can specify different percentage points for rush and non-rush periods.
- You can choose different percentage points for trains and subways
- You can choose changes to seasonal cards and changes in single tickets independently of each other
- You can change the level of parking places for P&R.
- You can specify changes in "general resistance" for walking and cycling.
- For cycles you can specify changes in the share of separated cycle path and Walk/cycle path. When you change the percentage points here, the implicit speed will change according to a speed model and will affects the cycle time attribute that enter the utility function of cycling. This will lead to a (minor) demand effect.

A technical further development of the implemented model has not been part of this project. Compared with Version 1, the calculation time in Version 2 has increased due to the complexity of the model and the use of more data observations. On a fast PC, the calculations in Version 2 will take up to 10 seconds. More challenging is that the excel file for Version 2 has become large (467 MB), so it takes a few minutes to open the file. Therefore, in the long term, it is recommended to implement the model as a web application.