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OTM7

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Abstract

In the period between October 2016 and June 2018 Vejdirektoratet has completed updating of the OTM model, version 6.1. The project includes three important improvements:

- Modelling of bicycle transport
- Estimating new values of travel time
- Updating of the route choice model and the demand model

Apart of the above improvements the zonal system has been improved dramatically, the model base matrices are built based on TU data and GPS data, and the road network has been improved.
The new OTM model, i.e. OTM 7, will be applied in autumn 2018 in the Copenhagen East Ring Road feasibility project.

Introduction

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Modelling of bicycle traffic

Modelling of bicycle transport was presented at Trafikdage 2017.

2015 VTT for the GCA

Vejdirektoratet has commissioned a study to quantify the willingness to pay of car and light van travellers in the Greater Copenhagen Area (GCA) to use a proposed new tunnel, the Harbour Tunnel (Havnetunnel), which would complete the Copenhagen Eastern Ring Road.
The key aim of this study was to quantify the willingness of car and light van travellers to pay (WTP) to use the proposed new tunnel under the Harbour in central Copenhagen. For that purpose new values of travel time (VTT) were calculated.

The study was restricted to cars and vans, including both drivers and passengers. It was also limited to investigate two specific travel responses: whether travellers would use a tolled alternative (a route choice response) and whether people would change their time of travel (a time-of-day response).
In total 3,688 surveys were undertaken for this study, all internet-based.
The VTT for the GCA are 12-15% higher than the existing (i.e. DATIV) values.
This project is described in details in Vuk, 2018.

Car assignment model

RP data

Observed routes (RP) were obtained from five GPS datasets. The datasets referred to as ACTUM, Test An EV and Copenhagen Municipality (KK) were provided by DTU, whereas the remaining two datasets were provided by the Danish Road Directorate. The data from the Road Directorate were much larger than the others, one collected from private cars and/or vans (not possible to distinguish between private cars and vans), while the other was collected from trucks.
The ACTUM and Copenhagen Municipality datasets were collected in 2011, Test An EV in 2010-2014 while data from Road Directorate originates from 2016. The five datasets consisted of:

- ACTUM (AC): 1,265 observations
- Copenhagen Municipality (KK): 122,369 observations
- Test An EV (Te): 6,469 observations
- Road Directorate (VD) Private Cars/Vans: 449,364 observations
- Road Directorate (VD) Trucks: 678,600 observations.

All data were a) filtered for errors and b) map-matched, prior to generating the choice-set for each OD pair.

Model estimations

In Table 1, the estimation results for all five datasets are presented together with calculated VTT for *fft* (free flow VTT) and *congt* (congested travel time VTT). The most plausible results are found from Model 1 for all car datasets (Actum, KK, Tee) whereas Model 2 is preferred for VD car+van and VD Trucks. This is an overall evaluation of the fit in the initial MNL models, but also results of final ML models.

Table 1 – Estimation results, single models, Cost and time estimated

Model specification		Actum M1		KK M1		TEE M1		VD car+van M2		VD Trucks M2	
	unit	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test
Beta_Cost	1/DKK	-1.57	-5.96	-0.611	-12.77	-0.524	-3.87	-0.181	-31.38	0.0875	36.96
Beta_TFree	1/min	-1.43	-6.35	-1.87	-26.23	-1.97	-8.39	-1.89	-203.2	-1.41	-105.66
Beta_Tcong	1/min	-2.18	-9.00	-1.59	-26.05	-2.07	-8.22	-2.31	-74.33	-1.66	-110.65
Beta_ps		1.13	4.36	1.35	20.79	1.27	6.11	1.52	137.27	1.14	85.8
VTTfree	DKK/Hour	54.65		183.63		225.57		626.52		-966.86	
VTTcong	DKK/Hour	83.31		156.14		237.02		765.75		-1138.29	
VTTcong/VTTfree		1.52		0.85		1.05		1.22		1.18	
Sample size:		335		3896		432		116940		110574	
Final log likelihood:		-633.611		-7971.68		-944.111		-284536.308		-198032.078	

It is seen that there is a large deviation in the VTT results and for VD trucks data, it was not possible to obtain parameters with plausible signs. Therefore, the GTC specification, as presented in Table 2, is preferred. Plausible congratios are obtained for Actum and KK data, whereas they seem quite large for Te, VD car/van and VD trucks.

Table 2 – Estimation results, single models, GTC specification

Model specification		Actum M1		KK M1		TEE M1		VD car+van M2		VD Trucks M2	
	unit	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test
Beta_Congratio*		1.21	1.23	1.35	7.80	1.8	4.91	2.13	37.79	2.45	48.17
Beta_GTC	1/min	-1.67	-9.36	-1.38	-30.93	-1.39	-9.53	-1.07	-167.81	-0.46	-83.89
Beta_ps		1.15	4.53	1.31	21.32	1.36	6.92	1.52	163.53	1.32	125.75
Sample size:		335		3896		432		116940		110574	
Final log likelihood:		-635.318		-8076.585		-964.171		-326083.992		-223592.401	

* t-tests against 1

It was agreed, since the VD data is much larger than the other datasets and thereby would have the largest influence on the result in a joint model, to only estimate the joint model on Actum, KK and TEE data. The joint car models are presented in Table 3, followed by the car/van models in Table 4 and the truck models in Table 10, all respectively as MNL and ML with variation on GTC and VTT below. As it was not possible to estimate the model with a free Beta_Congratio above 1 for the joint model, this has been fixed to 1.

Table 3 – Estimation results, Joint car models, GTC specification

Model specification		MNL M1		ML M1	
	unit	Value	Rob. t.test	Value	Rob. t.test
Beta_Congratio*		1.42	9.93	1	fixed
Beta_GTC	1/min	-1.49	-34.53		
mu_GTC				0.419	2.26
Beta_ps		1.42	23.92	0.636	1.44
Sigma_GTC				2.35	2.66
Sigma_VTT				0.964	47.71
Theta_KK*		0.907	-17.25	0.763	-1.30
Theta_Te*		0.95	-9.40	0.908	-1.23
Number of MLHS draws				300	
Sample size:		4663		4663	
Final log likelihood:		-13337.251		-12302.778	

* t-tests against 1

Table 4 – Estimation results, car/van, GTC specification

Model specification		MNL M2		ML M2	
	unit	Value	Rob. t.test	Value	Rob. t.test
Beta_Congratio*		2.13	37.79	1.87	66.41
Beta_GTC	1/min	-1.07	-167.81		
mu_GTC				0.576	57.75
Beta_ps		1.52	163.53	1.43	104.34
Sigma_GTC				2.00	73.72
Sigma_VTT				0.52	312.11
Number of MLHS draws				1000	
Sample size:		116940		116940	
Final log likelihood:		-326083.992		-297697.363	

* t-tests against 1

Table 5 – Estimation results, Truck models, GTC specification

Model specification		MNL M2		ML M2	
	unit	Value	Rob. t.test	Value	Rob. t.test
Beta_Congratio*		2.45	48.17	1.04	185.19
Beta_GTC	1/min	-0.46	-83.89	-0.504	-20.26
Beta_ps		1.32	125.75	1.52	138.1
Sigma_GTC				3.55	71.6
Sigma_VTT				0.392	6250.44
Number of MLHS draws				1000	
Sample size:		110574		110574	
Final log likelihood:		-223592.401		-209976.702	

* t-tests against 1

The present data does not include information about trip purpose so it is not possible to test variability in VTT due to this. Instead, the variability in VTT based on the time of day of the observed trips was tested using the joint MNL model. The resulting values are found in Table 6. Note that Beta_Congratio is not significantly different from 1 from 7-9 and 18-21.

Table 6 – Estimation results for time periods, (joint car MNL models)

Time interval		7-9		9-15		15-18		18-21		21-7	
	unit	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test	Value	Rob. t.test
Beta_Congratio*		1.02	0.14	1.53	11.57	1.47	3.73	1.09	0.58	1.34	2.41
Beta_GTC	1/min	-1.61	-12.34	-1.67	-25.74	-1.34	-14.74	-1.71	-8.49	-1.31	-9.69
Beta_ps		1.35	9.86	1.63	16.68	1.11	8.38	1.77	8.81	1.32	7.33
Theta_KK*		0.908	-5.48	0.882	-11.93	0.898	-9.19	0.917	-4.09	0.95	-7.25
Theta_Te*		0.944	-3.37	0.952	-4.57	0.935	-6.02	0.946	-2.80	0.98	-3.25
Sample size:		576		1955		1177		354		601	
Final log likelihood:		-1676.238		-5104.728		-3242.416		-1095.098		-2065.307	

* t-tests against 1

OTM demand modelling

New VTT in the demand model

For car modes, VTTs have been directly from the WTP project (Vuk 2018). These values have been provided separately for car driver and car passenger modes, vary by personal income band, and represent a car in average levels of congestion. These values can therefore be applied to the loaded assignment times directly. The values are summarised in the following tables.

In a few cases highlighted in yellow the VOTs do not increase monotonically with income band. This is followed from the sample enumeration approach whereby covariates such as trip length and duration also impact on predicted VTT, and in some cases differences in these covariates may have a greater impact than the income terms. It is noted that these cases tend to occur for the higher income bands which presumably are associated with lower sample sizes.

It is noted that the use of these average congestion VTTs in model application assumes that the congestion levels in future years remains at the same levels as the base year.

In addition to using the average car VTTs for loaded car time we will test terms for delay (i.e. loaded time minus unloaded time) to see if we can identify a significant difference between the valuations of delay and average car time.

Table 7: OTM 7.1 VTTs, commute and education, car drivers and passengers (2015 DKK/hr)

Income band	Car driver	Car passenger
0 - 200.000	50.27	48.47
2 - 300.000	62.20	61.26
3 - 400.000	68.04	64.56
4 - 500.000	71.26	68.56
5 - 600.000	75.03	64.74
6 - 700.000	78.09	70.64
7 - 800.000	80.25	75.52
> 800.000	85.72	82.90

Table 8: OTM 7.1 VTTs, business, car drivers and passengers (2015 DKK/hr)

Income band	Car driver	Car passenger
0 - 200.000	140.40	157.78
2 - 300.000	157.53	170.23
3 - 400.000	165.00	150.90
4 - 500.000	166.45	184.83
5 - 600.000	170.78	194.68
6 - 700.000	179.48	196.55
7 - 800.000	192.08	98.78
> 800.000	190.78	146.88

Table9: OTM 7.1 VTTs, home-shopping, car drivers and passengers (2015 DKK/hr)

Income band	Car driver	Car passenger
0 - 200.000	41.69	41.70
2 - 300.000	51.49	51.75
3 - 400.000	56.03	54.81
4 - 500.000	55.91	57.14
5 - 600.000	59.90	62.37
6 - 700.000	64.01	54.63
7 - 800.000	61.73	63.14
> 800.000	68.60	63.02

Table10: OTM 7.1 VTTs, home-other, car drivers and passengers (2015 DKK/hr)

Income band	Car driver	Car passenger
0 - 200.000	49.84	49.70
2 - 300.000	56.79	58.05
3 - 400.000	61.72	60.95
4 - 500.000	64.35	65.14
5 - 600.000	68.68	69.55
6 - 700.000	72.51	69.66
7 - 800.000	78.14	75.75
> 800.000	82.74	80.20

New public transport VTT in the demand model

Public transport (PT) alternatives were not presented to respondents in the WTP project, and there is no alternative source of PT VOTs. Therefore the approach that has been followed is to transfer the *ratio* of PT IVT to free flow time from the 2004 DATIV models and apply that to the new GCA values for car drivers in free flow conditions.

This approach gives reasonable VTT values for most purposes. However, for business the PT VTTs are significantly higher than the free flow car time values, particularly for bus. As a result the transferred PT VTTs were significantly higher than the new car free flow time values and the high values were judged to be unreasonable. Therefore for business it was decided to apply the new car driver free flow VTTs without modification for PT modes, i.e. to assume PT modes have the same VOTs as car driver.
For the out-of-vehicle time components (access & egress and wait time) we will estimate separate coefficients as per the OTM 7.0 models.
The resulting PT VOTs are summarised in the following tables.

Table 11: OTM 7.1 VTTs, commute and education, PT modes (2015 DKK/hr)

Income band	Train	Bus	Metro	Light rail
0 - 200.000	29.71	44.64	20.79	29.71
2 - 300.000	36.76	55.23	25.72	36.76
3 - 400.000	40.22	60.42	28.13	40.22
4 - 500.000	42.12	63.27	29.46	42.12
5 - 600.000	44.35	66.62	31.02	44.35
6 - 700.000	46.15	69.34	32.29	46.15
7 - 800.000	47.43	71.26	33.18	47.43
> 800.000	50.66	76.12	35.44	50.66

Table 12: OTM 7.1 VTTs, business, PT modes (2015 DKK/hr)

Income band	Train	Bus	Metro	Light rail
0 - 200.000	140.40	140.40	140.40	140.40
2 - 300.000	157.53	157.53	157.53	157.53
3 - 400.000	165.00	165.00	165.00	165.00
4 - 500.000	166.45	166.45	166.45	166.45
5 - 600.000	170.78	170.78	170.78	170.78
6 - 700.000	179.48	179.48	179.48	179.48
7 - 800.000	192.08	192.08	192.08	192.08
> 800.000	190.78	190.78	190.78	190.78

Table 13: OTM 7.1 VTTs, home-shopping, PT modes (2015 DKK/hr)

Income band	Train	Bus	Metro	Light rail
0 - 200.000	42.91	42.91	42.91	42.91
2 - 300.000	53.01	53.01	53.01	53.01
3 - 400.000	57.68	57.68	57.68	57.68
4 - 500.000	57.55	57.55	57.55	57.55
5 - 600.000	61.66	61.66	61.66	61.66
6 - 700.000	65.89	65.89	65.89	65.89
7 - 800.000	63.54	63.54	63.54	63.54
> 800.000	70.62	70.62	70.62	70.62

Table 14: OTM 7.1 VTTs, home-other, PT modes (2015 DKK/hr)

Income band	Train	Bus	Metro	Light rail
0 - 200.000	29.66	50.37	41.42	41.42
2 - 300.000	33.80	57.39	47.19	47.19
3 - 400.000	36.73	62.38	51.29	51.29
4 - 500.000	38.29	65.03	53.48	53.48
5 - 600.000	40.87	69.40	57.07	57.07
6 - 700.000	43.15	73.27	60.25	60.25
7 - 800.000	46.50	78.96	64.93	64.93
> 800.000	49.24	83.62	68.76	68.76

Final estimation work in the OTM 7.1 demand model will be done in April 2018.

References

De Borger, B. and M. Fosgerau. 2008. The trade-off between money and travel time: a test of the theory of reference-dependent preferences. Journal of Urban Economy. 64(1), 101–115.

Hess, S., Daly, A., Dekker, T., Ojeda Cabral and M. Batley, R. 2017. A framework for capturing heterogeneity, heteroskedasticity, non-linearity, reference dependence and design artefacts in value of time research. Transportation Research Part B, Volume 96, 126–149.

MOE. 2018. Betalingsvillighedsanalyse, Østlig Ringvej, Dataindsamling – pilot- og hovedundersøgelse

Vuk, Goran. 2018. New VTT for the Greater Copenhagen. Trafikdage 2018.