SOME VALIDATION TESTS OF THE OTM, ver. 5.0

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1. INTRODUCTION

The tactical traffic model for greater Copenhagen, the OTM model, was updated to its 5th version in a 2½-year long project lasting from January 2005 till April 2007. The model was updated especially for the purpose of the Metro City Ring project (approved in the Danish Parliament in June 2007). The biggest part of the efforts were placed on the data part of the model, where especially new base 2004 travel matrices were built. Apart from that, the model was completely re-estimated, starting from new values-of-time (VOTs), based on the newly completed data for the Danish national VOT project, and ending with the newly developed pivot-point procedure. Finally, the model zoning system, plan data and road/public transport networks were updated to reflect the new model base year of 2004.

The clients in the project were the Danish Ministry of Energy and Transport, the Danish Ministry for Financing, the Copenhagen and Frederiksberg municipalities, the Railway and Road Directories, and the Greater Copenhagen Authority. The project was completed by the Danish Transport Research Institute (DTF, DTU), the Centre for Transport and Traffic (CTT, DTU), TetraPlan, RAND Europe, COH ApS and COWI.

The aim of the paper is twofold. Firstly, we depict the structure of the new OTM demand model (chapter 2). Secondly, we present base year validations, sensitivity tests, and results from a back casting experiment (chapter 3 and 4). Conclusions are listed in the last section of the paper (chapter 5).

2. THE MODEL STRUCTURE

The new OTM model, version 5.0, is an updated version of the model from September 2000. The OTM 4.0 has been described in a number of international papers, the most important of which are "Validating the passenger traffic model for Copenhagen" (Vuk and Hansen, 2006) and "A Passenger Travel Demand Model for Copenhagen" (Jovicic and Hansen, 2003).

The OTM 5.0 is a weekday model (i.e. weekend travel is not modelled) for person and goods transport for the Greater Copenhagen Area (GCA). The GCA is represented by 818 internal zones, and the rest of the world is split into represented by 17 ‘port zones’. The model focus lies in passenger transport.

2.1 Modes, purposes and tour building

To model passenger transport, five modes are used; car driver, car passenger, public transport modes, bicycle and walk. Seven demand purpose segments are represented:

- home-work (HW),
- home-business (HBU),
- home-education (HE),
- home-shopping (HS),
- home-leisure (HO),
- non-home-based business (NHBU), and
- non-home-based other (OT).

Home-based tours are modelled for the first five segments, and trips are modelled for the two non-home-based segments. Activity chains (and trip chains) are not modelled in the current version of OTM.

To split the observed trip chains in the estimation panel data in order to fit them into the six purpose segments, a 'tour building' procedure was employed. Chains of trips, termed 'tours', starting and finishing at respondent's homes were identified. Next, the 'primary destination' of the tour was identified to define the purpose of the tour, using the following purpose hierarchy:

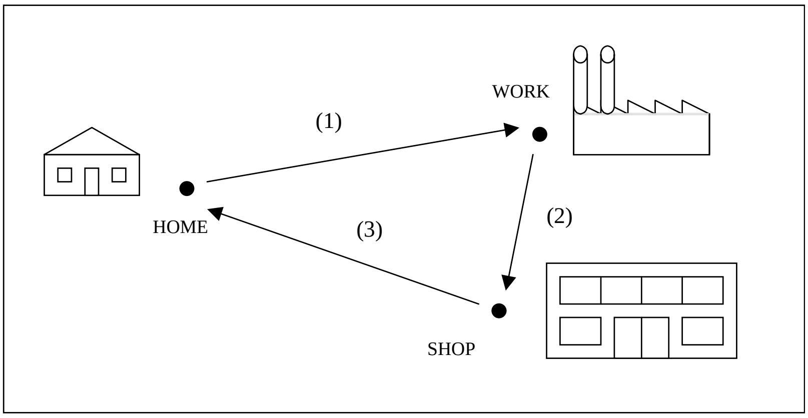
- commuting,
- employer's business,
- education, and
- other, which covers both home-shopping and home-leisure travel.

Ties (similar trip purposes in a trip chain) are resolved by taking the destination at which the most time was spent.

Home-based tours are modelled by assuming a direct return trip between the home and the primary destination. Once the home-based tours have been identified, the non-home-based trips – literally those trips where neither end is home – are identified. These are modelled independently from the home-based tours in OTM 5.

A example is shown in Figure 1, where a person has conducted two activities in a day: first a direct trip from home to work, and then on the return home a detour to the shops. This trip chain is modelled as one (return) home-work tour and one non-home-based other trip.

Figure 1 – A typical trip chain in the panel TU-data



2.2 Generation Models

Seven generation models have been developed, one for each of the purpose segments listed above.

For the five home-based segments, tour-based generation models have been developed. The models contain parameters to reflect differences in tour frequency with:

- occupation type,
- car availability,
- personal income band, and
- accessibility (measured using a purpose-specific ‘logsum’ from the mode-destination choice models).

In application, zonal level data is fed into the home-based generation models to predict the number of tours originating in each GCA zone by purpose.

For the two non-home-based trip segments, trip-based generation models were developed which contain parameters to reflect differences in trip frequency with:

- occupation type, and
- car availability.

In application, the non-home-based generation models are run to determine the number of non-home-based trips made by the residents of each GCA zone. These non-home-based trips are then distributed over origin zones according to the distribution patterns predicted by the home-based mode-destination choice models.

2.3 Mode-Destination Choice Models

The mode-destination choice models model the choice of mode and destination simultaneously using disaggregate models estimating using likelihood maximisation. Different ‘tree’ structures were tested to determine the relative sensitivity of the mode and destination choice decisions. The following table summarises the results of the these tests.

Table 1 – Implemented Tree Structures

Demand Model Purpose	Tree Structure
Commuting	T1: mode choice more sensitive to cost changes
Home-Business	T0: mode and destination choice equally sensitive
Home-Education	T0: mode and destination choice equally sensitive
Home-Education	T0: mode and destination choice equally sensitive
Home-Shopping	T0: mode and destination choice equally sensitive
Home-Leisure	T2: destination choice more sensitive to cost changes
Non-home business	T0: mode and destination choice equally sensitive
Non-home other	T0: mode and destination choice equally sensitive

The utilities of the mode and destination alternatives include terms for:

- size variables representing the attractiveness of each destination,
- cost terms for car (operating cost/km plus parking) and public transport,
- in-vehicle time terms for car and public transport,
- out-of-vehicle time terms for public transport,
- distance terms for cycle and walk,
- car availability parameters for car driver and car passenger, and
- mode specific constants.

The cost, in-vehicle time and out-vehicle time components for car and public transport have been converted into a common base unit of car free flow time using income-segmented values-of-time (VOTs) from the 2004 DATIV VOT study. The VOTs used for the lowest income band are summarised in the following table where non-home-based and home-based business segments are joined.

Table 2 – Values of Time in DKK/hr (1 Euro = 7.45 DKK)

VOT Component	HW	HE	HS	HO	OT	BU
Train IVT	21.3	23.3	16.5	16.9	14.0	85.7
Bus IVT	32.0	23.3	16.5	28.7	23.8	128.6
Metro IVT	14.9	23.3	16.5	23.6	19.6	60.0
Light Rail IVT	21.3	23.3	16.5	23.6	19.6	85.7
Car free flow	33.5	24.4	14.9	26.4	24.5	46.8
Car congested	69.4	24.4	14.9	71.6	54.4	130.8

The VOTs for the other four income bands are determined by applying fixed income multipliers to the values in table 2.

2.4 Time-of-Day Split

The demand model executes day matrices for five modes and seven travel purpose, giving 35 all-day matrices in total. However the demand matrices for home-based and non-home-based employer's business are merged before splitting into time periods, giving 30 all-day matrices. The day matrices are then split across seven time periods: 9pm-5am, 5am-7am, 7am-8am, 8am-9am, 9am-3pm, 3pm-6pm, and 6pm-

9pm. The split across the seven time periods is constant as it is observed in the base matrices, i.e. the OTM does not include a time period choice model.

2.5 Pivoting

The pivoting procedure makes best-estimate forecasts by predicting changes relative to a known base situation, defined by the base matrices (split by mode, purpose and time of day).

Pivoting is carried out at matrix cell level. For a given cell the predicted number of trips P is given by:

$$P = B.\ S_f/S_b$$

where: B is the observed (base year) trips

S_b is the base year synthetic trips

S_f is the future year synthetic trips

However, two considerations mean that it is not possible to apply this calculation as simply as straightforward. First, any of the three components on the right hand side of this equation may be zero making the calculation impossible or meaningless. Eight possible case arise - combinations of zero values – and these are detailed in the table below. Second, particularly when there is a land-use change affecting the whole of a zone, the change may be quite extreme and strict application of the formula above can result in an 'explosion' in the number of trips. In these cases it is better to 'pivot' by applying absolute growth, i.e. ($S_f – S_b$), rather than factor growth.

Table 3 – Pivoting Cases

<table>
<tr><th>Base
(B)</th><th>Synthetic Base
(S_b)</th><th>Synthetic Future
(S_f)</th><th colspan="2">Predicted
(P)</th><th>Cell Type</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td colspan="2">0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>>0</td><td colspan="2">S_f</td><td>2</td></tr>
<tr><td>0</td><td>>0</td><td>0</td><td colspan="2">0</td><td>3</td></tr>
<tr><td rowspan="2">0</td><td rowspan="2">>0</td><td rowspan="2">>0</td><td>Normal growth</td><td>0</td><td rowspan="2">4</td></tr>
<tr><td>Extreme growth</td><td>$S_f – X_1$</td></tr>
<tr><td>>0</td><td>0</td><td>0</td><td colspan="2">B</td><td>5</td></tr>
<tr><td>>0</td><td>0</td><td>>0</td><td colspan="2">$B + S_f$</td><td>6</td></tr>
<tr><td>>0</td><td>>0</td><td>0</td><td colspan="2">0</td><td>7</td></tr>
<tr><td rowspan="2">>0</td><td rowspan="2">>0</td><td rowspan="2">>0</td><td>Normal growth</td><td>$B.\ S_f / S_b$</td><td rowspan="2">8</td></tr>
<tr><td>Extreme growth</td><td>$B.X_2 / S_b + (S_f – X_2)$</td></tr>
</table>

where:

- extreme growth rule for cell type 4 applied for $S_f > X_1$

  where $X_1 = k_2.S_b$

  in the OTM 5 implementation $k_2 = 1$

  thus $X_1 = 1.S_b$

- extreme growth rule for cell type 8 applied for $S_f > X_2$

  where $X_2 = S_b . G$ and

  $G = k_1 + k_2 . \max (S_b/B, k_1/k_2)$

  with $k_1, k_2 > 0$

  in the OTM implementation k_1=0.5 and k_2=5

  thus $G = 0.5 + 5 . \max (S_b/B, 0.1)$

  $X_2 = S_b . [0.5 + 5 . \max (S_b/B, 0.1)]$

Further details about pivoting can be found in the paper by Daly, Tuinenga and Fox (2005) detailed in the references section.

3. MODEL VALIDATION

3.1 Travel distances and trip rates

At the heart of OTM 5.0 are the new 2004 base matrices. The new base matrices were developed using the following steps: data collection (panel data, postcard data and traffic counts), building of the matrices on the basis of panel and postcard data, and finally matrix adjustment obtained with the help of traffic counts.

Some 6.2 million person trips are made on an average workday in CGA in 2004 (table 4). Half of the trips are made by car (as driver or passenger), while the second half is, more or less, equally split between public transport, bicycle and walk modes. Travel purpose segments that count for most activities are home-leisure (HO), home-shopping (HS), home-work (HW) and non-home other (OT). Home-education (HE) and business (BU) segments count in total for only 13% of all trips.

The model trip lengths by mode and purpose (table 5) are obtained by multiplying zone-to-zone trips by zone-to-zone distances and averaging that by the total number of trips generated by a zone. Note that zone intern trips are not included. An average trip a person made in a workday in 2004 is 8,4 km long. Car and public transport average trips are 10-11 km long, while a bicycle trip is 4,2 km long and finally, a walk trip is 2,3 km long. The longest average trips are made when going to work or for business. As it could be expected, the education and shopping trips are the shortest in average.

Figure 2 shows how single trips are distributed per distance (for all travel modes and travel purposes). More than half of all trips made in an average workday in Greater Copenhagen in 2004 were up to 5 km long. On the other side, only about 10% of the trips are longer than 20 km, with just very few trips over 50 km.

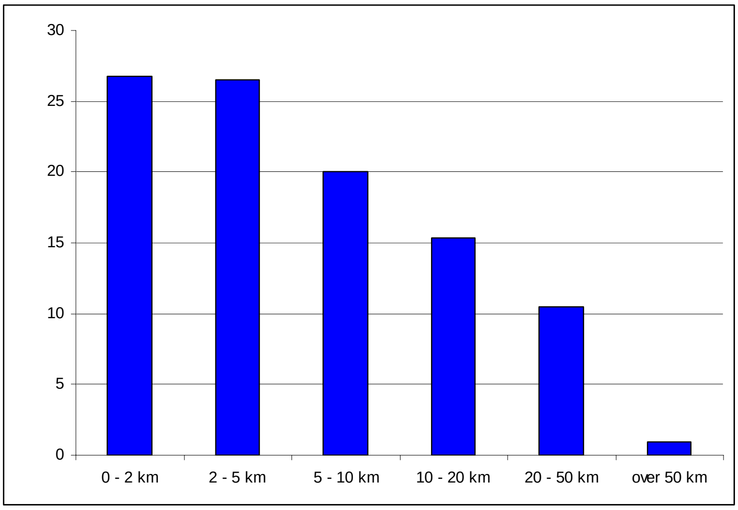
Table 4 – Person trips, ´000 per weekday in 2004

	HW	HE	HS	HO	OT	BU	Total
Car driver	550	40	396	621	378	192	2.177
Car passenger	133	77	202	444	173	52	1.081
Public transport	277	118	126	211	123	32	887
Bicycle	252	184	179	289	152	25	1.081
Walk	51	89	311	349	163	12	975
Total	1.263	508	1.214	1.914	989	313	6.201

Table 5 – Trip length, km

	HW	HE	HS	HO	OT	BU	Total
Car driver	15.8	10.8	7.8	9.5	10.4	12.7	11.2
Car passenger	14.2	7.7	7.9	9.7	10.1	12.6	10.0
Public transport	14.7	10.6	8.2	9.3	10.7	7.7	11.2
Bicycle	5.2	4.1	3.3	4.1	3.9	4.0	4.2
Walk	2.6	2.4	2.2	2.5	2.1	2.1	2.3
Total	12.7	6.4	5.8	7.4	8.0	11.1	8.4

Figure 2 – Distribution of trips per distance, %



When the model trips are multiplied by their distance and divided by the population, we obtain the person day average km travelled in 2004 to be about 28 km long (table 6). Almost a half of those km are travelled as car driver while only 20% by public transport. Only a bit more than 10% of the day-km is made by slow modes (i.e.

bicycle and walk). One third of the day-km is made in connection with work, while the three leisure type of activities (i.e. the sum of HS, HO and OT trip purposes) account for almost 60% of all day-km travelled.

Table 6 – Day person-km, km

	HW	HE	HS	HO	OT	BU	Total
Car driver	4.8	0.2	1.7	3.2	2.2	1.3	13.4 (47%)
Car passenger	1.0	0.3	0.9	2.4	1.0	0.4	5.9 (21%)
Public transport	2.2	0.7	0.6	1.1	0.7	0.1	5.4 (19%)
Bicycle	0.7	0.4	0.3	0.6	0.3	0.1	2.5 (9%)
Walk	0.1	0.1	0.4	0.5	0.2	0.0	1.2 (4%)
Total person-km per day	8.8 (31%)	1.8 (6%)	3.8 (13%)	7.8 (27%)	4.4 (16%)	1.9 (7%)	28.5 (100%)

The OTM 5.0 calculated trip rate is 3,3 trips/person/day (the matrix trip sum (see table 1) divided by the population sum from the model plan data). The observed trip rate in the 2000 TU-data was 3,1 and in the 2005 TU-data it was 3,2.

For the average person-km of 28.5 km/day and the calculated personal trip rate of 3.3 trips/day, we get that the average trip length is 8.6 km. This is very close to the model calculated average travel distance (see table 5) of 8,4 km. In the TU 1997-2005, the average observed trip length (weighted by the annual number of trips) was 9,07 km. A possible reason for the difference between the model-calculated average trip length and the TU-observed average trip length is that some short trips are not reported in the TU interviews.

3.2 Model elasticities

The travel cost and travel time model elasticities are obtained by changing the supply values, running the demand model and finally, comparing the scenario matrix sums with the base 2004 matrix sums (presented in table 1).

Table 7 shows the cost elasticities for car and public transport modes. The table shows that a 10% increase in driving costs will result in only 1% decrease (direct elasticity) in the number of car trips. That would consequently increase the public transport by 0.9%, bicycle trips by 0.7% and walk trips by 0.6% (across elasticities). The table also shows that a 10% increase in public transport fare would result in 4.2% decrease (direct elasticity) in the number of public transport trips. That gives an increase in the car trips by 0.6%, bicycle trips by 0.9% and walk trips by 0.7% (across elasticities). The rather high fare elasticity is likely contributed by large increases in public transport fares during the period from 2001 to 2004 (26% in fixes prices). The higher fare level, the more sensitive travellers will be towards fare changes. This needs to be considered in forecasting not to overestimate impacts of future fare changes.

Table 7 – Cost elasticity, all travel purposes

	Car	PT	Bicycle	Walk
Car	-0.10	+0.09	+0.07	+0.06
Public Transport	+0.06	-0.42	+0.09	+0.07

Table 8 shows the travel time elasticities for car and public transport modes. The table shows that a 10% increase in driving time will result in 1.5% decrease in the number of car trips. That would increase the public transport by 1.8%, bicycle trips by 1.3% and walk trips by 0.8%. The table also shows that a 10% increase in public transport time would result in 2.6% decrease in the number of public transport trips. That would consequently increase the car trips by 0.4%, bicycle trips by 0.6% and walk trips by 0.3%. Changes in public transport travel time have a less important impact to the public transport users relative to the changes in the public transport fare. Finally, the car users are much more elastic with respect to changes in travel time than to changes in driving costs.

Table 8 – Travel time elasticity, all travel purposes

	Car	PT	Bicycle	Walk
Car	-0.15	+0.18	+0.13	+0.08
Public Transport	+0.04	-0.26	+0.06	+0.03

Tables 9 and 10 present the same set of elasticities as table 7 and 8 but now only for the commuters. Car commuters are more harmed when the cost/driving time are changed than the car users in average (i.e. all travel purposes) - exactly the reason for segmentation by trip purposes.

Table 9 – Cost elasticity, commuters

	Car	PT	Bicycle	Walk
Car	-0.13	+0.11	+0.06	+0.02
Public Transport	+0.08	-0.33	+0.11	+0.05

Table 10 – Travel time elasticity, commuters

	Car	PT	Bicycle	Walk
Car	-0.24	+0.21	+0.14	+0.06
Public Transport	+0.06	-0.27	+0.08	+0.03

The EU report on car travel elasticities .TRACE (de Jong and Tegge, 1998) showed some similarities with the OTM´s car elasticities. The project reported that in the Netherlands France, the UK and Sweden the direct car elasticity for driving time was higher than for driving costs. However, it seems that the OTM´s elasticities in abosulte terms are generally lower than the other EU countries' elasticities. For instance, Swedish car travel cost elasticity was reported to be -0.14 while car travel time elasticity was -0.32. One explanation is that Danish car ownership is very low compared with many other EU countries.

3.3 Assignment results

Assignment results for the base 2004 year are discussed in this section. Table 11 shows the difference between the observed and calculated boardings by different public transport modes. In general, the figures compare well. The overestimation of the bus boardings happens due to the fact that the model converts all car/bike access/egress trips to the train network to be bus trips.

Table 11 – Number of boardings by public transport modes, in ´000

PT modes	Observed 2004	Calculated 2004	% difference
Bus	629	671	7
Metro	125	130	4
S-tog	320	325	2
Regional train	144	153	6
Lokalbaner	18	18	0
Total	1.236	1.297	5

In the development of the 2004 base year matrices, public transport trips and car trips have been adjusted to traffic counts (Nielsen et al., 2006). Preliminary results show a Percent Root Mean Square Error (%RMSE) of 18% between observed and modelled public transport flows calculated from

$$\%RMSE = \frac{\sqrt{\sum_{i=1}^{n} \frac{(x_i - Obs_i)}{n-1}}}{\frac{1}{n}\sum_{i=1}^{n} Obs_i}$$

where x_i is assigned traffic and Obs_i observed traffic at link i. Closer examination reveal, however, overestimations along some of the corridors. It suggests that a few additional matrix adjustments iterations probably should have been conducted. Also, counting is not exact, in particular, public transport count data are affected by uncertainties and sometimes inconsistencies.

Estimated and counted boarding passengers at train stations have also been compared in the validation of the model. Preliminary results show %RMSE to be 20% which is satisfactorily.

The divergence between observed and estimated car flow across selected corridors is small, typically 0-2%. Table 12, for instance, show observed car volumes versus modelled volumes across the Harbour corridor downtown Copenhagen. The match is acceptable for all four road links.

Preliminary calculations show a %RMSE of 13% at link level for all day car traffic which is within expectations.

Public transport and car assignment results need to be investigated based on larger data samples and split by time periods. It should also be noticed that since above results are based on network calibrations primarily downtown Copenhagen, more thoroughly calibrations should be performed before further comparisons.

Table 12 – Car traffic across the Harbour corridor

	Observed 2004	Calculated 2004	% difference
Knippelsbro	34,568	35,762	3
Langebro	67,971	72,193	6
Sjællandsbroen	57,158	51,211	-10
Kalvebod bro	90,158	91,681	2
Total	249,855	250,847	0

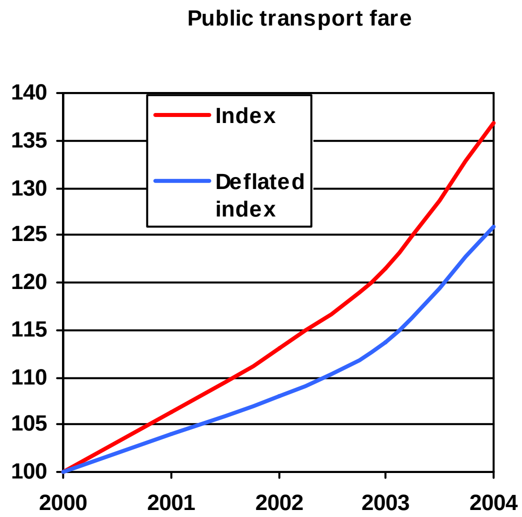
4. BACK CASTING TO THE YEAR 2000

The previous version of OTM (OTM 4.0) used 2000 as calibration year. Therefore, both input data (zonal data, networks etc.) and count data are available which facilitates to run OTM 5.0 in a back casting procedure from 2004 to 2000 to test forecasting capabilities of the model.

The back casting to year 2000 is relevant because the public transport system in GCA have changed radically in the period from 2000 to 2004. The metro system was opened in 2002 and therefore not available in year 2000. As a consequence of the metro, the bus service has been adjusted and a new service concept of high frequency buses (A-buses) has been introduced. Also a new train ring line across the city areas has been opened in the period.

The GCA population has grown 1.5% from 2000 till 2004, while the employment had fallen by 1.3% in the same period. The number of passenger cars per 1.000 inhabitants increased by about 5% from 2000 till 2004, but the central communities (i.e. the Copenhagen and Frederiksberg communities) kept the car ownership constant. The wage index rose by 14%, the price index rose by 8% and the deflated wage index rose by 5% in those four years. Figure 3 shows changes in public transport fares and petrol prices from 2000 till 2004. The figure shows that while the public transport fares rose quite dramatically in the 4-year period, the petrol prices actually went down.

Figure 3 – Development of the public transport fare and petrol prices between 2000 and 2004, %



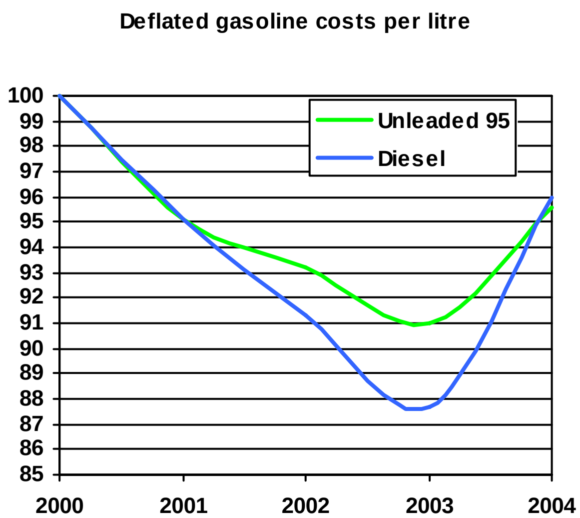


Table 13 shows the difference between the matrix sums when running the 2000 scenario (backcasting) and the matrix sums for the year 2004. In total, almost 3%

more trips are produced in 2004 compared to 2000. Though public transport has been improved in the period from 2000 to 2004 with metro, high frequency buses and train ring line, a decline of public transport users is calculated. The large fare increase in the period is an important reason for the lower number of public transport users.

Table 13 – Trips per average weekday in 2000 and 2004, ‘000

	2000	2004	% difference
Car driver	2,007	2,179	8.6
Car passenger	1,050	1,084	3.2
Public transport	947	889	-6.1
Bicycle	1,073	1,081	0.7
Walk	967	975	0.8
Total	6,044	6,208	2.7

The relative divergence by public transport is similar to base year 2004. The counted number of passenger boardings was 1,293,000 on an average weekday in 2000 which decreased to 1,236,000 boardings in 2004. Thus, we observe a decrease of 57,000 passenger boardings from 2000 to 2004. OTM 5.0 calculates a decrease of 61,000 passenger boardings.

The bus system has experienced a large loss of passengers in the period from 2000 to 2004 of more than 20% compared to the model estimate of a decrease of slightly less than 20%. The S-train system has also lost passengers in the period, about 5%. The model estimates a decrease of 10% of passengers in the train system. On the other hand the heavy train system has gained about 7% more passengers particular from long distance travel to/from Sweden and Jutland and Funen. The model estimates an increase of 2% influenced by the exogenous port zone traffic assumptions.

While the overall changes in public transport ridership are reflected very well by the model, there are some discrepancies looking at the separate modes. Likely it is caused by difficulties to model route choice behaviour exactly, in particular, in cases of several available parallel routes.

Table 14 shows a comparison between the counted and modelled car traffic across the Harbour corridor for the year 2000. As it can be seen in the table, the differences are rather small.

Table 14 – Car traffic across the Harbour corridor for the year 2000; counted versus modelled traffic

	Counted 2000	Modelled 2000	Abs. difference	% difference
Knippelsbro	34,600	35,144	514	1
Langebro	68,500	65,643	-2,857	-4
Sjællandsbroen	51,100	42,686	-8,414	-16
Kalvebod bro	76,900	79,042	2,142	3
Total	231,100	222,485	-8,615	-4

5. CONCLUSIONS

One of the central methodological ideas behind the OTM is the pivot-point procedure. The procedure implies that the model forecast are compared to the observed travel patterns, as depicted in the base 2004 travel matrices, before producing the scenario matrices. This base 2004 matrices are therefore of a large importance in this model. The OTM 5.0 contains 210 base matrices, split by 5 travel modes, 6 travel purposes and 7 day periods. The matrix sum shows that in an average workday in 2004, there were made 6,2 million trips in the Greater Copenhagen, most of them by car (some 50%), and the fewest by public transport (only 14%).

Running the model for a number of future scenarios shows that car users (across different travel purposes) is rather inelastic with respect to changes in driving costs, i.e. for an increase of 10% in driving costs only 1% of the car trips would change to other modes. Opposite to that, as much as 4.2% of the public transport trips would switch to other modes if public transport fare increased by 10%. With respect to changes in travel time, an average car user seems to care a lot if the driving time increases, i.e. 10% increase in driving time would result in 1.5% decrease of car trips, which is more than in the case of changes in driving costs. Opposite to that, the public transport users are less annoyed by increased travel time, as 10% increase in time would shift only 2.6% of the trips to other modes and that is almost only a half of importance in changes in public transport fare.

If we focus only on elasticities with respect to home-work activity then car time and cost elasticities are much higher than in the case of an average car user (across different travel purposes). The car commuter time elasticity is -2.4% while the cost elasticity is -1,3%. It seems that congestion on the Greater Copenhagen road network influences behaviour of car users significantly.

The assignment results for the base 2004 year show some good results within expatations. For instance, the modelled total number of public transport boardings is just 5% higher than the observed. A traditionally very difficult mode to model, the bus traffic, is now only 7% higher than the observed bus traffic. The total car traffic across the Harbour corridor is identical between the modelled and the observed ones.

An interesting experiment was conducted by running a model backcast for the year 2000. Two rather important changes from 2000 till 2004 are that metro was not existed in 2000, and that on one side the public transport fare increased dramatically while the petrol price dropped from 2000 till 2004. It is also noticed that the income had increased from 2000 till 2004 just as well as the car ownership, and the GCA population. When those changes are coded in the model one would expect the following model reactions: an increase in total number of trips from 2000 till 2004, an increase in car trips and a decrease in public transport trips. A comparison of the model produced matrices for the year 2000 and for the year 2004 shows that total trips rose by nearly 3% in those years, the car trips rose by 6,6% while the public transport trips decreased by 8,5%.

The backcasting assignment results reveal similar changes as the actual observed traffic. In the period from 2000 to 2004, a decrease of 57,000 passenger boardings per weekday in public transport is counted while the model estimates a decrease of 61,000 boardings. Within the public transport modes, the model calculates correctly a large decrease in bus riders, a moderate decrease in S-rain passenger and an increase in heavy train passengers.

The total car traffic across the Harbour corridor is almost identical between the modelled and the observed ones. In general, the difference between observed and modelled car flows is only slightly larger for 2000 and in base year 2004.

References

de Jong, G. and O. Tegge. ”TRACE, Cost of Private Road Travel and Their Effect on Demand, Including Short and Long Term Elasticities”. European Commission Directorate-General for Transport. 1998.

Jovicic, G. and C.O. Hansen. "A Passenger Travel Demand Model for Copenhagen". Transportation Research Part A: Policy and Practice. Volume 37. Issue 4. Page 333-349. 2003.

Vuk, G. and C.O. Hansen. "Validating the passenger traffic model for Copenhagen". Transportation. Volume 33. Issue 4. Page 371-392. July 2006.