42178 – Transport System Analysis E21

Portfolio exercise IV

The page limit of the full exercise is 12 pages. Feel free to put additional material in appendices but please keep essential results within the text so that your answers are understandable without appendices.

Exercise 1

We are as consultants asked to construct a transport model for commuters in the city of Labtown.

The following things are known.

- The city is divided into 20 zones.
- 50% of the population commutes every day from every zone.
- Each commuter is assumed to produce one work tour (home->work->home) per day. Hence, we do not need to consider trip generation in the modelling.

Data

The following data sources are available.

1) **Application data (appdata)**: Data represent the population of Labtown. The variables in the data are

Name	**Description**	**Dimension**
ResiZone	Zone of residential zone	1,…,20
DestZone	Zone of destination	1,…,20
Dist	Distance (KM)	
Cc	Car cost (DKK)	
Ct	Car travel time (Minutes)	
Pc	Public cost (DKK)	
Pt	Public travel time (Minutes)	
AE	Access-Egress to Public transport from the home (Minutes)	
CarStatus	Average number of cars in the household in the zone	

PopResi	Total population in residential zone	
EmpResi	Total employment in residential zone	
PopDest	Total population in destination zone	
EmpDest	Total employment in destination zone	

2) **Zone data.** Total employment and population in each zone. These variables are included in the application data.

3) **Model structure** and **parameters**:

The model structure to consider is a nested-logit model with choice of destination at the "upper level" and choice of mode at the "lower level". Please, note that to simplify notation μ_d is already included in the coefficient related to modes, i.e. $V_n(m|d)$.

$$V_n(walk|d) = k_{walk} + \beta_{wt} wt(d)$$

$$V_n(bike|d) = k_{bike} + \beta_{bt} bt(d)$$

$$V_n(car|d) = k_{car} + \beta_{cc} cc_n(d) + \beta_{ct} ct_n(d) + \beta_{cstat} CarStatus_n$$

$$V_n(carp|d) = k_{carp} + \beta_{cpt} ct_n(d)$$

$$V_n(pub|d) = \beta_{pc} pc_n(d) + \beta_{pt} pt_n(d) + \beta_{ae} AE_n$$

$$V_n(d) = \alpha ln(Emp(d) + 0.15 Pop(d))$$

Remember that $P_n(d)=(\exp(V_n(d)+\mu_d I_d)/\Sigma_n \exp(V_n(d)+\mu_d I_d)$

where $I_n(d) = ln\left(\Sigma_m e^{V_n(m|d)}\right)$.

You may assume that $wt(d)$ can be based on "Dist" from the application data and an average speed of 6 KM/Hour. Similarly, you may assume that $bt(d)$ can be based on "Dist" and an average speed of 12 KM/Hour.

The tour characteristics are based on one-way values for the corresponding tour. The parameters reflect this so you can enter the one-way values directly into the model even though the model output consist of tours.

Parameter	**Value**	**Description**
k_{walk}	1.5	Walk constant
k_{bike}	2	Bike constant

k_{car}	0.5	Car constant
k_{carp}	-0.5	Carp constant
β_{wt}	-0.12	Walk time parameter (U/min)
β_{bt}	-0.12	Bike time parameter (U/min)
β_{cc}	-0.05	Car cost parameter (U/DKK)
β_{ct}	-0.06	Car time parameter (U/min)
β_{cstat}	1	Car status parameter
β_{cpt}	-0.1	Car passenger time parameter (U/min)
β_{pc}	-0.05	Public transport cost parameter (U/DKK)
β_{pt}	-0.05	Public transport time parameter (U/min)
β_{ae}	-0.03	Public transport access-egress parameter (U/min)
μ	0.7	Logsum parameter
α	1	Size parameter

4) Observed OD matrix for all modes.

Name	**Description**	**Dimension**
FromZoneID	FromZone ID	1,…,20
ToZoneID	ToZone ID	1,…,20
Trips_w	Walk trips	
Trips_b	Bike trips	
Trips_c	Car trips	
Trips_cp	Carp trips	
Trips_p	Public transport trips	

Task 1 – implement the model

Based on the application data, the model structure, and the parameters you are asked to implement the model. Open the application data in Excel and calculate the following;

- The mode choice utility function.
- The conditional mode choice probabilities $P_i(m|d)$ for each representative person (indexed by the zone i) and each destination d for all modes m.
- The destination choice utility function.
- Destination choice probabilities $P_i(d)$ for each representative person i and each destination d.
- The joint probability $P_i(m,d)$ of mode and destination for each person i.

Hint: Refer to the formulas for the Nested Logit Model Section 8.2.

Now, based on the implemented model you are supposed to calculate the.

- Average mode shares for the population.

Task 2 – Calculate OD matrices and calibrate the model

Based on the model, which is tour based, calculate the corresponding OD matrices for all modes. Since we do the exercise in Excel it is difficult to calculate OD(i,j)=GA(i,j)+GA(j,i). But you are welcome to do it, e.g. using VLOOKUP. Otherwise, it is OK just to approximate this by OD(i,j)=2*GA(i,j). If you do it the easy way you should explain in your report why this is not correct.

Based on the observed OD matrix, you are now asked to evaluate whether the model replicates the market shares of the observed OD matrix. If not, you are asked to calibrate the model so that the mode-choice shares are identical to the market shares of the OD matrix. The observed market shares can be found in the appendix. A few iterations should be enough. You should report how well your model replicates the observed OD mode shares.

Hint: Apply algorithm 15.1.

Task 3 – Analyse model sensitivity

Evaluate the model sensitivity with respect to cost and time attributes for trips. Hence, calculate elasticities based on a 10% increase of the main variable in each simulation. This can be done using either your modelled GA matrices or OD matrices. You decide what you prefer. Report the elasticities in a table similar to the one below. Please comment on the elasticities. Do you find them realistic relative to each other?

Mode	**CC + 10%**	**CT + 10%**	**PC + 10%**	**PT + 10%**
Walk				
Bike				

Car driver				
Car passenger				
Public				

Appendix

Mode	OD mode shares
Walk	4.03 %
Bike	14.19 %
Car	62.32 %
Carp	8.83 %
Pub	10.63 %

Exercise 2

Task 1 – Apply the model from Exercise 1 for policy analysis

It is considered whether to introduce a new pricing policy for public transport in Labtown. This policy involves that every public transport tour, irrespectively of the length will be priced 10 DKK, i.e the one-way ticket is 10 DKK so pubcost (pc) should be changed to 10 DKK. Apply pivoting to predict the effects of this policy in terms of demand changes.

Hint: refer to Section 15.4.

Task 2 – Cost-benefit analysis of the PT price reduction policy

The transport organisation in Labtown would like to know whether the PT price reduction in task 1 is valuable to the society. As input for a cost-benefit analysis, they therefore ask you to calculate the user benefit of this policy and compare the user benefit to the loss in ticket revenues. To calculate the user benefit, you may use rule of a half, see 17.3 in the book.

You may assume that the social value of travel time (SVTT) for all modes is equal to 70 DKK/hr and the social value of access egress time to be 1.5*SVTT.

NB. In task 2, it is OK not to consider the feedback of the travel time change due to fewer cars on the mode choice.

Task 3 – Cost-benefit analysis with feedback

In the transport organisation of Labtown, a traffic engineer argues that given current commute traffic in Labtown, the car travel time has an elasticity wrt. car demand of 0.5. Discuss how such an effect would affect your results in Task 2 and try to implement a solution that considers this elasticity.