42178 – Transport System Analysis E21
Portfolio exercise III

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

Consider the data set "ModeChoice" suited for a discrete choice estimation for the choice of mode. It includes the four modes: 1=walk, 2 = bike, 4 = car driver, and 6 = public transport.

1. **Estimation**:

   The following two logit models based on utility functions 1 and 2, respectively, have been implemented in R.

   Utility function 1: $V_{ni} = k_i + a \cdot \text{cost}_{ni} + b \cdot time_{ni}$

```
Coefficients :
                Estimate Std. Error  z-value  Pr(>|z|)
(Intercept):2 -0.3849777  0.0524489  -7.3401 2.136e-13 ***
(Intercept):4  0.1192669  0.0562477   2.1204   0.03397 *
(Intercept):6 -1.9548787  0.0950367 -20.5697 < 2.2e-16 ***
TT            -0.0430375  0.0024383 -17.6503 < 2.2e-16 ***
TC            -0.0457363  0.0066804  -6.8464 7.574e-12 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log-Likelihood: -4271.1
```

   Utility function 2: $V_{ni} = k_i + a \cdot \ln(\text{cost}_{ni}) + b \cdot time_{ni}$

```
Coefficients :
                Estimate Std. Error  z-value  Pr(>|z|)
(Intercept):2  0.1097849  0.0697467   1.5741 0.1154753
(Intercept):4  1.3413546  0.1610092   8.3309 < 2.2e-16 ***
(Intercept):6 -0.7295991  0.1975212  -3.6938 0.0002209 ***
TT            -0.0267934  0.0018525 -14.4631 < 2.2e-16 ***
log(TC)       -0.4489316  0.0561628  -7.9934 1.332e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log-Likelihood: -4257.4
```

Discuss the results and decide which of the specifications you prefer. Argue why. The remainder of the exercise, you should only base on your preferred specification.

2. Market Shares:

Based on the estimated parameters, calculate the individual probabilities for each alternative in each observation. Compute the market shares for each mode in the base situation and compare to the observed market shares.

3. Value of Time:

In mode choice models, we can calculate the value-of-time (VOT). This is equal to:

$$VOT_{ni} = \left(\frac{\partial V_{ni}}{\partial t_i}\right) / \left(\frac{\partial V_{ni}}{\partial c_i}\right)$$

where t and c refer to travel time and travel cost. Calculate the average VOT for the sample in the data.

4. **Elasticities**:

For travel cost and time, calculate the aggregate direct and cross elasticities for each mode based on probability-weighted averages. Present these aggregated results, e.g. in a four by four elasticity matrix and discuss the results.

5. **Model specification**:

Now, you would like to investigate whether there is a difference in preferences for using public transport between male and female respondents. Make a cross table presenting how the market shares are split across gender.

In the output presented below, the interaction variable Ptfem has been included, which is only one in the public transport alternative and only if the user is female:

Utility function 3: $V_{ni} = k_i + a \cdot \ln(\text{cost}_{ni}) + b \cdot time_{ni} + c \cdot Ptfem_{ni}$

```
Coefficients :
                Estimate Std. Error  z-value  Pr(>|z|)
(Intercept):2  0.1323373  0.0698482   1.8946   0.05814 .
(Intercept):4  1.4104197  0.1616258   8.7265 < 2.2e-16 ***
(Intercept):6 -1.2657003  0.2334577  -5.4215 5.909e-08 ***
TT            -0.0263811  0.0018367 -14.3629 < 2.2e-16 ***
log(TC)       -0.4747656  0.0565327  -8.3981 < 2.2e-16 ***
Ptfem          0.9936726  0.1872407   5.3069 1.115e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -4241.7
```

Discuss the results. Are the market shares predicted for the new model different than those predicted by the model in exercise 1.2? Why/Why not?

6. **Simulation, scenario 1:**

   Now, politicians would like you to evaluate what happens with market shares if the cost of going by car increases by as much as 50%! Calculate the new market shares and comment on your results; ①.

7. **Simulation, scenario 2:**

   A new more environmental friendly car enters the world market. Unfortunately, it is more expensive and slower than the present car. Given that you have already implemented the car cost increase in 6) (for ordinary cars), it is still 20% more expensive than the ordinary car and 20% slower. What will be the market share for the new automobile according to your model? ②

   Describe how the new alternative mode "steals" market shares from the other modes. What is the relative change in market share for each alternative. Is this reasonable given that the new mode is quite similar to the car mode? What would be a reasonable substitution pattern?

Hint ①: To evaluate such a policy scenario, simulation is needed, based on the parameter estimates from your preferred model.

Hint ②: In this simulation, assume that the preferences (parameters) for the new alternative are the same as for car driver.

Exercise 2 – Nested Logit

In order to test if there are correlation among some pairs of alternatives, the following nested logit models have been estimated:

1. Individual vs. Public (1,2,4 vs. 6)
2. Motor vs. other (1,2 vs. 4,6)
3. Car vs. others (4 vs. 1,2,6)
4. Car and Walk vs. others (1,4 vs 2,6)

2.1 Model structure

Based on the following estimation output, discuss the results and decide which specification you prefer:

Model 1:

```
Coefficients :
                Estimate Std. Error z-value  Pr(>|z|)
(Intercept):2  0.1138409  0.0582645  1.9539   0.05072 .
(Intercept):4  1.1661130  0.2252301  5.1774 2.250e-07 ***
(Intercept):6 -1.6938436  0.3929061 -4.3111 1.625e-05 ***
TT            -0.0217119  0.0048553 -4.4718 7.757e-06 ***
log(TC)       -0.3976270  0.0753545 -5.2768 1.315e-07 ***
Ptfem          0.9702954  0.1936421  5.0108 5.421e-07 ***
iv             0.8096602  0.1697895  4.7686 1.855e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -4240.9
```

Model 2:

```
Coefficients :
                Estimate Std. Error  z-value  Pr(>|z|)
(Intercept):2  0.1246273  0.0900192   1.3845  0.166220
(Intercept):4  1.4882848  0.2234059   6.6618 2.705e-11 ***
(Intercept):6 -2.9741392  1.8581193  -1.6006  0.109462
TT            -0.0287164  0.0018723 -15.3374 < 2.2e-16 ***
log(TC)       -0.4333611  0.0619228  -6.9984 2.589e-12 ***
Ptfem          1.3547628  0.4927758   2.7492  0.005973 **
iv:walkbike    1.3542781  0.2198555   6.1599 7.281e-10 ***
iv:motor       1.5677248  0.5606816   2.7961  0.005172 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -4238.3
```

Model 3:

```
Coefficients :
                Estimate Std. Error  z-value  Pr(>|z|)
(Intercept):2  0.1184777  0.0717569   1.6511   0.09872 .
(Intercept):4  1.3419513  0.1908308   7.0322 2.034e-12 ***
(Intercept):6 -1.2302779  0.2107375  -5.8380 5.284e-09 ***
TT            -0.0262162  0.0015688 -16.7113 < 2.2e-16 ***
log(TC)       -0.4600616  0.0599948  -7.6684 1.732e-14 ***
```

```
Ptfem          0.9591937  0.1839166   5.2154 1.834e-07 ***
iv             0.9540365  0.0720781  13.2361 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -4241.5
```

Model 4:

```
Coefficients :
                Estimate Std. Error z-value  Pr(>|z|)
(Intercept):2 -0.1822955  0.1530549 -1.1910    0.2336
(Intercept):4  0.9418312  0.2178064  4.3242 1.531e-05 ***
(Intercept):6 -1.1596390  0.1825249 -6.3533 2.107e-10 ***
TT            -0.0205695  0.0031359 -6.5593 5.405e-11 ***
log(TC)       -0.3153978  0.0742410 -4.2483 2.154e-05 ***
Ptfem          0.7133131  0.1587160  4.4943 6.981e-06 ***
iv:bikepub     0.6319911  0.1062113  5.9503 2.676e-09 ***
iv:carwalk     0.7340071  0.1214080  6.0458 1.487e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Log-Likelihood: -4237.4
```

2.2 Model structure

Based on the estimated parameters for the preferred model, calculate the individual probabilities for each alternative in each observation. Compute the aggregate market shares and VoT for each mode in the base situation.

2.3 Cost elasticities

Now, politicians would like to know the cost elasticities related to car cost and time (both direct and cross). You can derive the elasticities based on a simulation where you increase car cost (time) by either 1% or 10%. Compare these to the elasticities from exercise 1.4.

2.4 Scenario and calibration

Again, you are asked to analyse what happens when a new more environmentally friendly car enters the market. It is more expensive and slower than the present cars. It is 20% more expensive than the ordinary cars and 20% slower. Discuss how to include the new alternative in your model! You are also informed that aggregate population shares for each mode are:

walk - 0.15, bike - 0.25, car - 0.39, pub - 0.08, and new car - 0.13.

Please update your model so that it includes the new alternative and meets the aggregate shares on the first two decimals of the shares. What are the new ASCs in your updated model? ③

Discuss the substitution patterns of you updated model. What will happen in a scenario where the new_car reaches the same travel cost and travel time as the existing car? You are welcome to illustrate this either by calculating market shares in the scenario or calculate elasticities of the updated model.

Hint ③: In this scenario, assume that the preferences (cost and time parameters) for the new alternative are the same as for car. You can then calibrate the alternative specific constants using algorithm 15.1.