Appendix

Homework assignment

In this assignment, you will work with a simplified but complete four-step model for the central part of the Research Triangle region (Wake, Durham, Orange, and Chatham counties). Specifically, you will be evaluating the Chatham Park development, which will eventually add 22,000 new homes to Pittsboro and the surrounding region, increasing the population of this area by several times.

For this project, you will use the My First Four Step Model R package and a model I have already estimated for the Research Triangle region. You will compare three scenarios:

1. A baseline based on current population and employment locations
2. A Chatham Park scenario, adding 22,000 households to Pittsboro
3. (Extra credit) A Chatham Park scenario that additionally widens Highway 15-501 between Pittsboro and Chapel Hill to three lanes each way

Before you can run the model, you will need to install the package. To do this, run the following R code in RStudio:

```
install.packages("devtools") # if you do not already have the devtools package
devtools::install_github("mattwigway/MyFirstFourStepModel")
```

All of the code you will need to run the model is available in this R file, which you should download and save somewhere you can find it again.

If you plan to leave this assignment until the last minute (I get it, we've all been there), **I highly suggest you at least open the R file and make sure you can run the entire model as soon as possible, to give us time to troubleshoot in case you run into software issues.** Feel free to reach out to me if you have any issues running the model. If you do run into issues, make sure you're using R 4.3 or later. Several of the steps may take thirty minutes to an hour to run on your machine, so be sure to leave enough time to run them.

Work through the `chatham_park_model.R` file you downloaded, running the code one section at a time (like we did with regression) and answer the following questions in a separate document that you upload to Canvas. You should not need to make any modifications to the code.

1. In the AM Peak home-based work trip production model, how many additional trips is an additional worker in the expected to produce? Is this statistically significant? [0.5 point]
2. Include your map of trip generation. Does the map look like you would expect? [0.5 point]

3. In the trip distribution model, the β's are not the same across all trip types. Compare the home-based work and home based other betas. Which is smaller? What does this mean? Does this match your expectations? [1 point]
4. Include your map of trip distribution for AM peak HBW trips from central Carrboro. Does the map match your expectations? [0.5 point]
5. In the mode choice model, relative to car (the base mode), does increasing trip distance (dist_km) increase or decrease the probability of choosing walk? [0.5 point] (extra credit: is it statistically significant? [0.5 point])
6. What are the forecast mode shares in the baseline scenario? [0.5 point]
7. Include your map of forecasted PM Peak congestion for the baseline and Chatham Park case. How do you expect PM Peak congestion to change when Chatham Park is fully occupied? [1 point]
8. Based on your findings, what changes (if any) would you propose to the Chatham Park development and/or the surrounding transportation system (1-4 sentences)? [0.5 point]

Extra credit

The scenario we tested above added a lot of households to Pittsboro/Chatham Park, with no improvements to the transportation system in the area. In both of the model runs above, the R code referred to `model$networks$baseline`. Replace all references to `model$networks$baseline` with `model$networks$widen_15_501` in the code that ran the Chatham Park scenario, which models upgrading US 15-501 between Chapel Hill and Pittsboro to a grade-separated, limited access, three lane each way freeway.

9. Include your map of forecast congestion after 15-501 has been widened. How does the widening affect the changes in congestion you observed in the previous question? [1 point]
10. What significant effect of roadway widening does the model not account for, and do you think this undermines the results? [1 point]

Network scenario full code

This is the full code for the network scenario, including all Way IDs:

```
model$networks$widen = model$networks$baseline |>
  modify_ways(
    # US 15-501 between Pittsboro and Chapel Hill
    c(
      "16468788", "133051274", "16471803", "285898984",
       "16476716", "822063218", "29335841", "709833467",
      "29335943", "29335943", "654023608", "654023604",
       "29336020", "29336065", "29336043",
      "29336065", "29336065", "1119560022", "29336065",
       "29336065", "690900371", "133051279", "29336072",
      "690900390", "29336325", "29336326", "29336327",
      "29336328", "29336338", "29336335", "29336336",
      "116792787", "138138864", "29336430", "138138830",
       "116792819", "50370797", "50370799", "50370826",
```

```
      "50370836", "133051276", "133051275", "133051277",
       "133051276", "133051276", "133051278", "133051278",
      "1119560050", "690900383", "1028209511", "138138830",
       "138138830", "1064169631", "138138830", "138138830",
      "1064169646", "138138830", "285898976", "625793296",
       "285898977", "712336832", "654023612", "285898984",
      "285898984", "285898992", "694843964", "1064169630",
       "1064169647", "398223958", "712336806", "398223959",
      "712336808", "518951244", "709833464", "713044971",
      "1265931335", "574612704", "614242454", "713044971",
      "614242450", "614242450", "614242453", "614242454",
      "614242453", "690900386", "690900353", "690900357",
      "690900390", "694843965", "709833465", "709833466",
      "998595933", "712336807", "712336820", "712336809",
      "712336821", "712336826", "712336827", "998595932"
    ),
    lanes_per_direction=3,
    highway_type="motorway"
  )
```

Modifications to trip distribution model estimation

β_c for the trip distribution model is calibrated for each trip type by using Brent's method to solve the problem:

$$\min_{\beta} \left(\frac{\sum_{i,j,d_{ij}<\tilde{d}} P_i A_j d_{ij}^{\beta} - \sum_{i,j,d_{ij}\geq\tilde{d}} P_i A_j d_{ij}^{\beta}}{\sum_{i,j} P_i A_j d_{ij}^{\beta}} \right)^2$$

where $\tilde{d}$ is the median trip distance for the trip type under consideration (subscript c suppressed for readability), and other variables are as defined previously.

This is slightly different than the function presented in Merlin (2020). It divides by total weighted destinations to make the function have a single minimum; otherwise $\beta = -\infty$ is also a minimum as the total weighted destinations are zero. I also replace the absolute value with squaring to make the derivative continuous at the optimal value.