Appendix

Deriving individual Ramsey prices

We begin by repeating the objective function from equation (11)

\[
\min_{t_{ij},\ldots,t_J} \sum_{j=1}^{J} \frac{\exp\left(\alpha_j + \beta_j \left(tc_{ij} + t_j\right) + \phi_j X_{ij}\right)}{\beta_j} + \lambda \left( R - \sum_{k=1}^{K} t_k \cdot \exp\left(\alpha_j + \beta_j \left(tc_{ij} + t_j\right) + \gamma Y_{ij} + \phi_j X_{ij}\right) \right) \tag{A1}
\]

The first order condition with respect to \(t_j\) is

\[
\exp\left(\alpha_j + \beta_j \left(tc_{ij} + t_j\right) + \phi_j X_{ij}\right) - \lambda \left(\exp\left(\alpha_j + \beta_j \left(tc_{ij} + t_j\right) + \gamma Y_{ij} + \phi_j X_{ij}\right) + t_j \exp\left(\alpha_j + \beta_j \left(tc_{ij} + t_j\right) + \gamma Y_{ij} + \phi_j X_{ij}\right) \beta_j\right) = 0 \tag{A2}
\]

This can be simplified as

\[
\frac{1}{\lambda \exp(\gamma Y_{ij})} - (1+t_j \beta_j) = 0 \tag{A3}
\]

Since (A3) holds for all \(j=1,\ldots,J\) it follows that

\[
\left(1+t_j \beta_j\right) = \left(1+t_k \beta_k\right) \tag{A4}
\]

and \(t_j \beta_j = t_k \beta_k\).

Deriving population Ramsey prices

The minimization problem for a population of recreation users under our model assumptions is
where AR is the aggregate revenue target. The derivative with respect to $t_j$ is

$$\sum_{i=1}^N \exp(\alpha_{iy} + \beta_j (tc_{iy} + t_j) + \phi_j X_{iy}) - \lambda \left( \sum_{i=1}^N \exp(\alpha_{iy} + \beta_j (tc_{iy} + t_j) + \gamma Y_{iy} + \phi_j X_{iy}) + t_j \beta_j \sum_{i=1}^N \exp(\alpha_{iy} + \beta_j (tc_{iy} + t_j) + \gamma Y_{iy} + \phi_j X_{iy}) \right).$$

Define the aggregate quantities

$$\Theta^j_N = \sum_{i=1}^N \exp(\alpha_{iy} + \beta_j (tc_{iy} + t_j) + \gamma Y_{iy} + \phi_j X_{iy})$$

$$\Omega^j_N = \sum_{i=1}^N \exp(\alpha_{iy} + \beta_j (tc_{iy} + t_j) + \phi_j X_{iy})$$

and substitute and set equal to zero to state the first order condition for $t_j$:

$$\Omega^j_N - \lambda \left(1 + t_j \beta_j \right) \Theta^j_N = 0.$$  \hspace{1cm} (A8)

Solving for $1/\lambda$ and using the conditions for $t_j$ and $t_k$ we have

$$\frac{(1 + t_j \beta_j) \Theta^j_N}{\Omega^j_N} = \frac{(1 + t_k \beta_k) \Theta^k_N}{\Omega^k_N}.$$  \hspace{1cm} (A9)

This suggests that the optimal fees for a population of users is a weighted version of the single user case, where weights are based on aggregate trip demand at each site. For situations with small income effects ($\gamma \approx 0$) we have $\Theta^j_N \approx \Omega^j_N$ so that $\Theta^j_N / \Omega^j_N \approx 1$ and

$$t_j \beta_j \approx t_k \beta_k,$$  \hspace{1cm} (A10)

thereby matching the single-user case.