Appendix

Derivation of Equation (3)

We can write the effects at each site symmetrically like so:

(S1) $$\frac{dx_1}{dF_1} = \frac{\partial g_1}{\partial p_1} + \frac{\partial g_1}{\partial c_1}\frac{dx_1}{dF_1}/L_1 + \frac{\partial g_1}{\partial c_2}\frac{dx_2}{dF_1}/L_2$$

(S2) $$\frac{dx_2}{dF_1} = \frac{\partial g_2}{\partial p_1} + \frac{\partial g_2}{\partial c_1}\frac{dx_1}{dF_1}/L_1 + \frac{\partial g_2}{\partial c_2}\frac{dx_2}{dF_1}/L_2$$

Re-arranging (S1):

(S3) $$\frac{dx_1}{dF_1} = \frac{\frac{\partial g_1}{\partial p_1} + \frac{\partial g_1}{\partial c_2}\frac{dx_2}{dF_1}/L_2}{1 - \frac{\partial g_1}{\partial c_1}/L_1}$$

Substituting into (S2):

(S4) $$\frac{dx_2}{dF_1} = \frac{\partial g_2}{\partial p_1} + \frac{\partial g_2}{\partial c_1}\left[\frac{\frac{\partial g_1}{\partial p_1} + \frac{\partial g_1}{\partial c_2}\frac{dx_2}{dF_1}/L_2}{L_1 - \frac{\partial g_1}{\partial c_1}}\right] + \frac{\partial g_2}{\partial c_2}\frac{dx_2}{dF_1}/L_2$$

$$\frac{dx_2}{dF_1} = \frac{\partial g_2}{\partial p_1} + \frac{\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial p_1}}{L_1 - \frac{\partial g_1}{\partial c_1}} + \left[\frac{\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial c_2} + \frac{\partial g_2}{\partial c_2}}{L_1 - \frac{\partial g_1}{\partial c_1}}\right]\frac{dx_2}{dF_1}/L_2$$

(S5) $$\left[1-\frac{\frac{\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial c_2}}{L_2}}{L_1-\frac{\partial g_1}{\partial c_1}}-\frac{\partial g_2}{\partial c_2}/L_2\right]\frac{dx_2}{dF_1}=\frac{\partial g_2}{\partial p_1}+\frac{\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial p_1}}{L_1-\frac{\partial g_1}{\partial c_1}}$$

(S6) $$\left[\left(L_1-\frac{\partial g_1}{\partial c_1}\right)\left(1-\frac{\partial g_2}{\partial c_2}/L_2\right)-\frac{\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial c_2}}{L_2}\right]\frac{dx_2}{dF_1}=\left(L_1-\frac{\partial g_1}{\partial c_1}\right)\frac{\partial g_2}{\partial p_1}+\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial p_1}$$

Finally, change in per-mile demand at site two from a fee at site one is:

(S7) $$\frac{dx_2/dF_1}{L_2}=\frac{\left(L_1-\frac{\partial g_1}{\partial c_1}\right)\frac{\partial g_2}{\partial p_1}+\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial p_1}}{\left(L_1-\frac{\partial g_1}{\partial c_1}\right)\left(L_2-\frac{\partial g_2}{\partial c_2}\right)-\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial c_2}}$$

Or alternatively:

(S7') $$\frac{dx_2}{dF_1}=\frac{\left(1-\frac{\partial g_1}{\partial c_1}/L_1\right)\frac{\partial g_2}{\partial p_1}+\frac{\partial g_2}{\partial c_1}\frac{\partial g_1}{\partial p_1}/L_1}{\left(1-\frac{\partial g_1}{\partial c_1}/L_1\right)\left(1-\frac{\partial g_2}{\partial c_2}/L_2\right)-\left(\frac{\partial g_2}{\partial c_1}/L_2\right)\left(\frac{\partial g_1}{\partial c_2}/L_1\right)}$$

The first term in the denominator is positive, but the second term is negative. Similarly in the numerator, the first term is positive, but the second is negative. Therefore, it is not possible to sign dx_2/dF_1 in general.