

Online Appendix for
“Efficiency and Substitutability of Transit Subsidies and Other Urban Transport
Policies”

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PARAMETER VALUES

In this Appendix we describe the methodology and main sources for estimating the parameter values which are summarized in Table 2. The conversion rate used for Santiago is one dollar equals 550.64 Chilean pesos based on observed exchange rates of August, 2009. For London, all monetary values are in 2002 USD (using 2002 exchange rate for GBP to U.S. dollar); In Table 2 we use the UK price index to show monetary values in 2009 prices.

General Parameters

In order to generate a congested situation we set the three factors affecting congestion: the total demand, the periods' duration, and the road capacity. After looking at some main roads size and passenger load at peak periods, we first fix road capacity to the capacity of an urban three-lane street and then apply a factor of 0.6 to the road capacity to take into account traffic signals. The passenger load is determined by the product of total demand per km. and trip length. For London, we obtain average trip length dividing the annual miles travelled per person and annual trips per person, both from U.K. ONS (2008). For Santiago, the parameter is set based on official studies. The number of hours per period is based on the daily motorized trips per time of day of each city. Finally, total demand is set, based on observations for passenger load, to generate a congested situation given the road capacity and trip length.

Income groups used for Santiago are the ones defined in the demand model estimated for Santiago (SECTRA, 2005) and we assume that people are distributed along the corridor equally and in the same proportion as the number of dwellings of each group in the city.

We assume constant car occupancy, using the average value for each city in peak period. For London, it is the car occupancy used by Parry and Small (2009), and for Santiago it is obtained from the report of the latest survey of mobility in Santiago (SECTRA, 2003a).

Car operating costs for London are the values estimated by The Automobile Association for U.K. on their running cost guides 2010/2011 (AA, 2010) subtracting their estimate for tolls and considering the annual miles travelled per person by car from U.K. ONS (2008). In the case of Santiago the car operating cost is from Basso et al. (2011) adapted to fit the units used in our application.

Demand

All the relevant data for the parameters for the logit model in Santiago, including the observed values of attributes for modal constant calibration, are from two studies carried out by the Planning Ministry of Chile namely SECTRA (2003a) and SECTRA (2005). After having the cost parameter and the estimated values of time per period, the (generalized) time parameter is easy to obtain. With the observed data we calibrate the modal constants by solving for each income group the equation that equals observed modal share with the prediction given by our model using the bus fare, car costs, travel time, waiting time and walking time reported for the conditions on which the model parameters were estimated. This procedure gives us the value for the 4 modal constants that are consistent with our three-nest two-mode model for each of the income groups. As we point out in Section II, data for London demand model is from U.K. DfT (2004), TfL (2007) and Litman (2012), and once the parameters for the model are calculated the procedure is basically the same for the modal constant. In addition, in both applications, we set the value of the scale parameter μ and the share of people not traveling (needed to calibrate the modal constants) in such a way that the implied inter-temporal elasticities and the total demand elasticity is low and similar to the values reported in the the literature.

For Santiago, each income group is defined by SECTRA (2005) and Table A1 shows the observed modal share adjusted for our two-mode two-period model and the distri-

bution of the population over the income groups.

TABLE A1—OBSERVED MODAL SHARE AND PERCENTAGE OF POPULATION OF EACH INCOME GROUP. SANTIAGO

Income group	Peak		Off-peak		Population
	Bus share	Car share	Bus share	Car share	
Low income	0.93	0.07	0.92	0.08	0.14
Middle-low income	0.82	0.18	0.82	0.18	0.28
Middle income	0.64	0.36	0.64	0.36	0.32
Middle-high income	0.38	0.62	0.44	0.56	0.17
High income	0.10	0.90	0.14	0.86	0.09

Source: SECTRA (2005).

Note: The observed modal shares are adjusted based on the data from SECTRA (2005).

In London, during peak period the adjusted observed car modal split is 27 percent and bus modal share is 73 percent. In the off-peak the modal split changes to 21 and 79 percent for car and buses respectively.

The generalized travel time is a weighted sum of travel time, waiting time and walking time, where the following weights were used: 1, 2.5 and 2 respectively for London (DfT, 2009) and 1, 1.93 and 3.63 respectively for Santiago (SECTRA, 2005).

Transport times

Bus stop operation has two components, the boarding and alighting of passengers and the congestion. We assume that all passengers board by only one door and that this process is the one that determines the time spent on the operation.¹ The time that a passenger takes to board is set based on quick board values estimated for United States (TRB, 1985), London (York, 1993) and for Santiago (Fernández et al., 2008), which point out values between 1.5 and 3 seconds per passenger.

The total time spent because of congestion, t_d , is a function with three components: a constant time, queuing time and internal delay. The constant time a bus spends on the stop is also obtained from the same studies used for the boarding time (TRB 1985, York 1993, Fernandez et al. 2008). This time includes the doors operation, bus accommodation to the side-walk and acceleration/deceleration of the bus, which together can reach values from 9 seconds to 25 seconds, depending among other things

¹This could be for two reasons: boarding is slower because the payment and alighting of passengers takes less time because generally it occurs on many doors.

on technology issues. In relation to the other components of bus congestion function at the bus stop, research has shown that a good way of studying queuing time (d_q) and internal delay (d_i) is with microsimulation, because of the several factors that affects these times (Fernández and Planzer, 2002; Fernández and Tyler, 2005). Incorporating a microsimulation model to an already complex optimization problem does not seem a sensible path, so what we do is to use non-linear functions for d_q and d_i which were obtained from microsimulation exercises by Fernández et al. (2000). These functions model both queuing and internal delay times as functions of the saturation degree of the bus stop (f^t/K_p) and the number of passengers that board and alight each bus. Functional forms for bus stop capacity (K_p), internal delay (d_i) and queuing time (d_q) in terms of optimization variables are:

$$K_p^t = \left(a_p \cdot \frac{Y_{tb}}{H^t \cdot f^t \cdot p} + b_p \right) \cdot \ln \left(\frac{Y_{tb}}{H^t \cdot f^t \cdot p} \right) + c_p \cdot \frac{Y_{tb}}{H^t \cdot f^t \cdot p} + d_p$$

$$d_i^t = \left(a_{i1} + a_{i2} \cdot \frac{f^t}{K_p^t} \right) \cdot \frac{Y_{tb}}{H^t \cdot f^t \cdot p} + \left(b_{i1} + b_{i2} \cdot \frac{f^t}{K_p^t} \right) \cdot \frac{Y_{tb}}{H^t \cdot f^t \cdot p} + c_i \cdot \left(\frac{Y_{tb}}{H^t \cdot f^t \cdot p} \right)^2$$

$$d_q^t = \left(a_{q1} + a_{q2} \cdot \frac{Y_{tb}}{H^t \cdot f^t \cdot p} + a_{q3} \cdot \left(\frac{Y_{tb}}{H^t \cdot f^t \cdot p} \right)^2 \right) \cdot \exp \left(\frac{f^t}{K_p^t} \left(b_{q1} + b_{q2} \frac{Y_{tb}}{H^t \cdot f^t \cdot p} \right) \right)$$

where t stands for period, a_p , b_p , c_p , d_p , a_{jn} , b_{jn} and c_i are parameters estimated by Fernández et al. (2000) and each one depends on the number of berths per bus stop. We use the values reported for a bus stop with two berths.

Bus operating costs

The cost study made in Santiago (SECTRA, 2003b) is a prediction for costs of firms with different bus size and directly reports G_b and G_v of equation (10) for 4 different bus size (40, 80, 120 and 160 passengers). With these parameters in hand we simply perform a linear regression to obtain a initial slope and intercept of both functions $G_b(k)$ and $G_v(k)$ in dollars per hour. Besides this estimation, we amplify the parameters based on observations and the financial report of the bus system made by the Ministry of Transport (Transantiago, 2010) in order to adjust the prediction data to the situation

observed in Santiago since 2007 when Transantiago was implemented and the different bus size firms were in operation.

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