A PANEL DATA MODEL TO FORECAST THE EFFECTS OF A RADICAL PUBLIC TRANSPORT INNOVATION

M. Francisca Yáñez, Juan de Dios Ortúzar
Pontificia Universidad Católica de Chile

Benjamin Heydecker
University College London

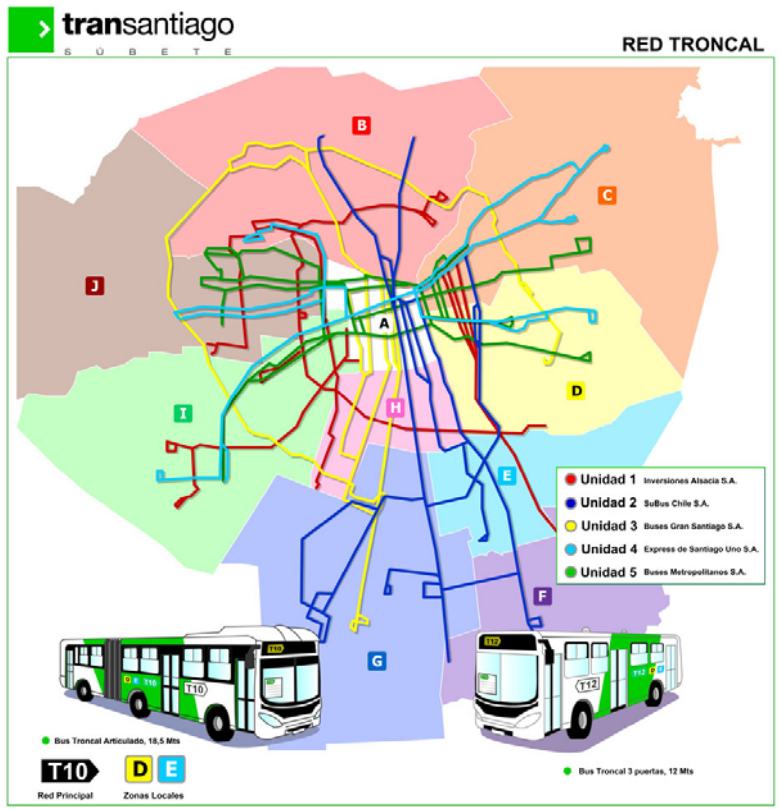
Contents

- Brief overview of Transantiago
- Construction of the panel
- Statistical analysis
- Modelling
- Conclusions

Brief Overview of Transantiago

- Transantiago is a new public transport system
  - Main aim: improve public transport in Santiago, giving priority and stopping public transport decline.

- New integrated system:
  - Feeder & trunk buses
  - Metro
  - Integrated fare
  - Implemented in “big bang” fashion



Before Transantiago

- Buses:
  - long routes
  - driver competition
  - rude drivers
  - high frequency
  - low quality
- Metro:
  - middle and high income people only
  - 1.3 million pass/day

- System
  - high noise, pollution, accidents & assaults

After Transantiago

- Buses:
  - shorter routes
  - no street competition
  - lower frequency
- Metro
  - overloaded (from 1.3 to 2 million pass/day)
  - used by people in all walks of life
- System
  - lower noise & pollution and no assaults

Construction of the *Santiago Panel*

- Sample size: 303 individuals.

- Dates of the survey:
  - Wave 1: December, 2006.
  - Wave 2: May, 2007.
  - Wave 3: December, 2007.
  - Wave 4: August 2008.
  - Wave 5: December 2008.

  } Initial design

- Information sources: Face to face interviews and precise measurement of level-of service variables.

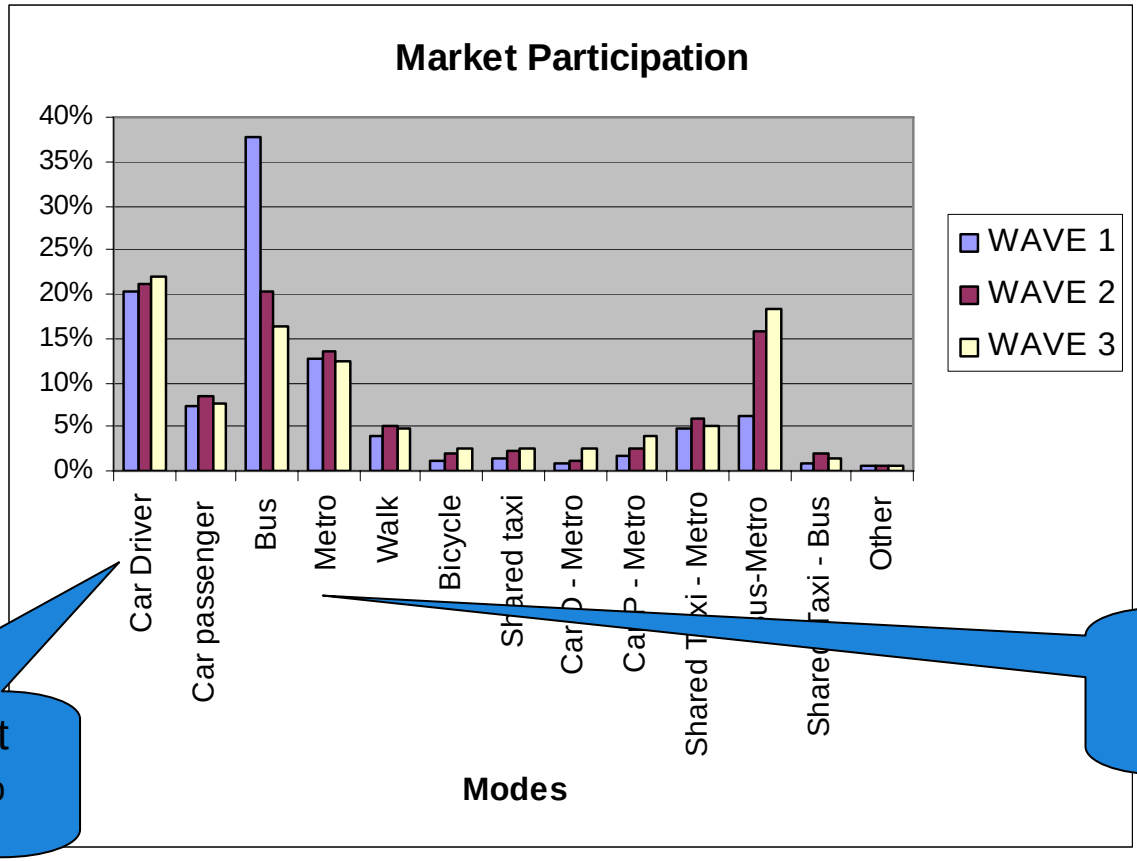
Attrition

- Maintenance methodologies:
  - Providing incentives
  - Maintaining contact
  - Using the same interviewer
  - Conducting face to face interviews

- Consequences:
  - Attrition wave 2: 5%
  - Attrition wave 3: 3%

Statistical Analysis

46% of respondents changed their transport mode after the introduction of Transantiago

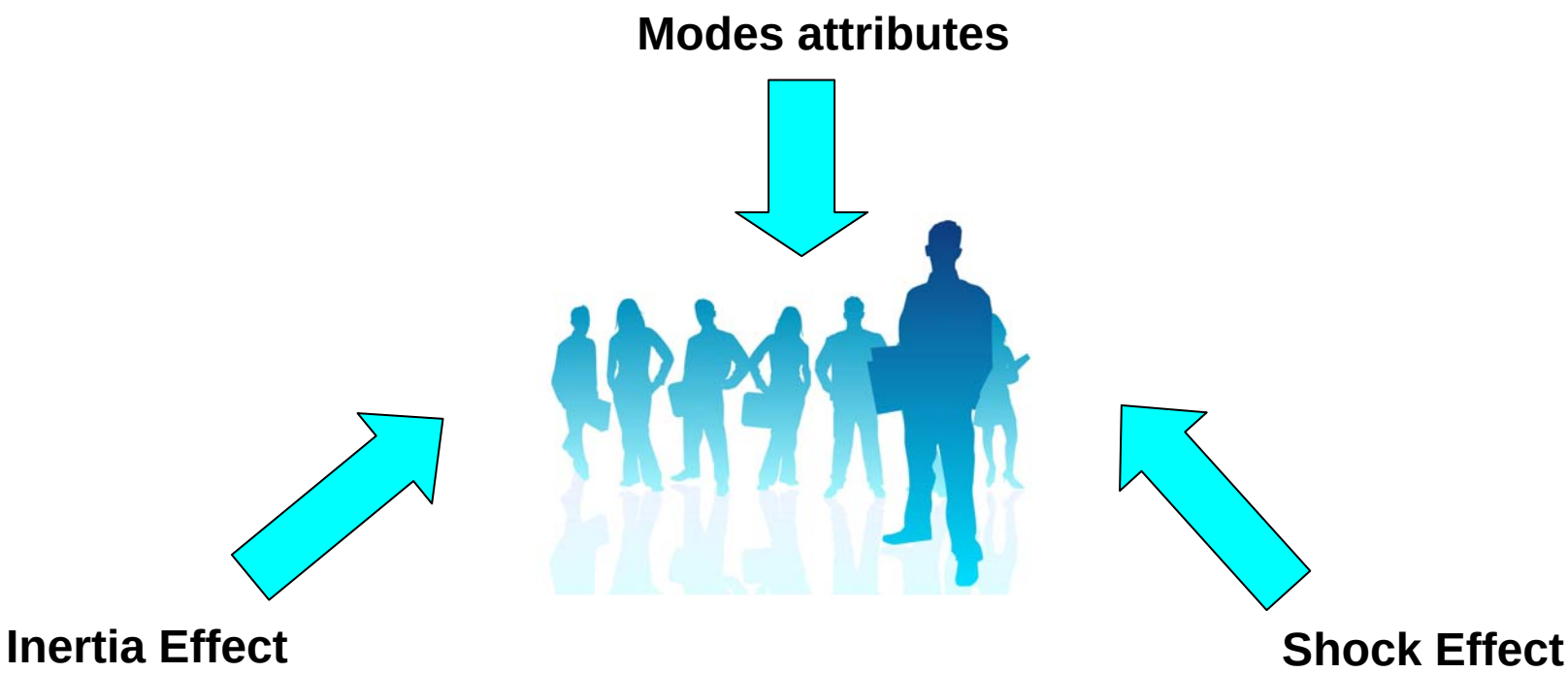


Private Transport
27,6% → 29,5%

Public Transport
63,9% → 56,2%

Modelling

- An individual *q* uses commonly the same option to travel to work.
- In t_s the transport system changes by the introduction of a new public policy.



Model specification

Utility function:

$$U_{iq}^{w} = X_{iq}^{w} \cdot \beta_{i}^{w} + \alpha_{i}^{w} + \left(S^{w}{}_{i} + \varsigma_{q} \cdot \sigma_{S_{i}^{w}}\right) \cdot X_{iq}^{w} \cdot \beta_{i}^{w} \cdot \Phi(t - t_{s}) + \varepsilon_{iq}^{w}$$

Where:

X_{iq}^{w} vector of attributes of option *i* for individual *q* on wave *w*;

β_{i}^{w} vector of parameters for option *i*;

S_{i}^{w} vector that represents the shock effect of the policy

$$\Phi(x) = \begin{cases} 1 & \text{x} \geq 0 \\ 0 & \text{x} < 0 \end{cases}$$

$$\varepsilon_{iq}^{w} = \upsilon_{iq} + \zeta_{iq}^{w}$$

Model 4 (the best): assumes that the ASCs do not capture satisfactorily the shock effect.

proposes that the shock effect:

- is different among modes
- varies among individuals
- has the power to modify the parameters value

$$S^{w}_{i} \neq 0 \Leftrightarrow \text{shock effect exists}$$

Details

Empirical results

- The parameter signs are correct
- The relationship between time coefficients is as expected: $|\beta_{\text{travel time}}| < |\beta_{\text{walk time}}| < |\beta_{\text{wait time}}|$.
- Model with shock effect is the best.
- Every shock coefficient, except for shared taxi, is significant.
- Only two modes, car driver and shared taxi, have positive shock effect
- Combined modes have the highest shock values.
- SVT is 118.3 Ch$/min (*US$ 1,180 per month*), similar to previous findings (Munizaga at al., 2006) where the SVT was 113.6 Ch$/min (*US$ 2,000 per month*).

Conclusions

- A shock can modify the valuation process of alternatives, causing changes in individual utility functions.
- The best model considers that the shock effect is different per each alternative, and varies among individuals.
- The shock is generated by the introduction of Transantiago, a policy that modifies only the public transport system, but there are effects in both public and private modes. In fact, the best model shows the highest shock values for the combined modes.
- More complex models should be formulated if we want to model changing systems in order to capture the effect of the new policy in the individuals' choice process.
- We are only including the shock effect. Inertia effects have not been considered in this paper → Next step will evaluate the introduction of inertia and study the relation between inertia and shock over time.

Many thanks

	Model 1	Model 2			Model 3			Model 4		
		Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3
No. of observations	3659	3659			3659			3659		
Number of cars	1.610	1.650			1.410	1.590	2.210	1.610		
t-test vs 0	*8.920*	*8.810*			*4.870*	*4.600*	*6.200*	*6.930*		
CW (mean)	-0.021	-0.021			-0.034	-0.012	-0.006	-0.042		
t-test vs 0	*-5.980*	*-5.520*			*-5.610*	*-2.360*	*-1.300*	*-7.070*		
CW (st.dev.)	0.016	0.022			0.004	0.004	0.004	0.024		
t-test vs 0	*-2.680*	*-3.530*			*0.970*	*0.970*	*0.970*	*-4.350*		
TRAVEL	-0.049	-0.060			-0.171	-0.013	-0.086	-0.101		
t-test vs 0	*-7.390*	*-8.340*			*-7.260*	*-1.610*	*-7.770*	*-6.200*		
WAITING	-0.107	-0.117			-0.383	-0.070	-0.070	-0.311		
t-test vs 0	*-9.110*	*-8.990*			*-8.300*	*-4.120*	*-3.620*	*-8.770*		
WALKING	-0.065	-0.066			-0.185	-0.067	-0.022	-0.182		
t-test vs 0	*-11.360*	*-10.870*			*-10.510*	*-6.040*	*-2.700*	*-11.450*		
INTERCHANGES	-0.085	-0.409			-0.711	-1.210	-0.066	-0.673		
t-test vs 0	*-0.570*	*-1.250*			*-0.440*	*-3.090*	*-0.160*	*-0.990*		
COMFORT (mean)	2.110	2.740				2.030	2.930	6.480		
t-test vs 0	*7.060*	*8.730*				*8.350*	*7.410*	*5.580*		
COMFORT (st.dev.)	1.320	1.970				0.308	0.308	0.336		
t-test vs 0	*2.250*	*3.840*				*0.740*	*0.740*	*3.440*		
TRANSANT	2.440	3.120				2.510		9.470		
t-test vs 0	*6.300*	*7.040*				*6.360*		*5.660*		

	Model 1	Model 2			Model 3			Model 4		
		Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3
MSC CD	8.370	0.502	5.840	13.400	-2.530	4.750	7.240	5.170	9.970	11.200
t-test vs 0	*5.320*	*0.590*	*4.820*	*5.940*	*-4.120*	*6.280*	*6.900*	*2.340*	*5.710*	*5.340*
MSC CP	8.360	0.488	6.050	13.300	-3.150	4.980	7.610	4.520	9.550	10.300
t-test vs 0	*5.310*	*0.570*	*5.000*	*5.900*	*-5.020*	*6.600*	*7.300*	*2.030*	*5.410*	*4.880*
MSC SH T	8.510	0.255	6.180	13.800	-0.617	4.790	7.250	6.710	13.200	13.700
t-test vs 0	*5.390*	*0.290*	*5.050*	*6.130*	*-1.040*	*6.390*	*6.900*	*3.110*	*6.990*	*6.350*
MSC METRO	9.190	1.820	6.210	14.100	1.250	5.190	7.250	8.550	8.090	8.990
t-test vs 0	*5.850*	*2.190*	*5.180*	*6.260*	*2.340*	*7.140*	*6.990*	*3.910*	*4.630*	*4.350*
MSC BUS										
t-test vs 0										
MSC WALK	10.200	1.670	7.790	15.800	0.021	6.940	9.090	7.800	9.340	11.300
t-test vs 0	*6.450*	*1.920*	*5.980*	*6.980*	*0.030*	*8.740*	*6.510*	*3.520*	*5.210*	*5.300*
MSC BIKE	7.910	-0.361	5.130	13.900	-3.470	3.850	8.530	3.720	8.440	11.100
t-test vs 0	*5.020*	*-0.410*	*4.110*	*6.120*	*-5.380*	*5.070*	*8.100*	*1.670*	*4.700*	*5.150*
MSC CD-METRO	7.000	-0.489	2.760	11.800	0.029	1.100	5.730	5.870	3.640	6.960
t-test vs 0	*4.390*	*-0.520*	*2.070*	*5.230*	*0.020*	*1.330*	*5.090*	*2.610*	*1.990*	*3.490*
MSC CP-METRO	7.870	0.791	4.220	12.300	0.999	2.310	6.490	7.240	5.400	6.470
t-test vs 0	*4.990*	*0.920*	*3.400*	*5.520*	*0.600*	*3.440*	*6.000*	*3.310*	*3.210*	*3.210*
MSC SH T-METRO	9.060	1.660	5.570	13.700	3.190	3.290	7.060	9.180	6.110	7.120
t-test vs 0	*5.740*	*1.940*	*4.570*	*6.170*	*1.920*	*5.140*	*6.570*	*4.200*	*3.650*	*3.540*
MSC BUS-METRO	9.370	1.550	6.090	14.100	2.300	3.580	7.760	8.980	7.090	8.620
t-test vs 0	*5.940*	*1.840*	*5.010*	*6.350*	*4.190*	*5.720*	*7.290*	*4.110*	*4.290*	*4.370*
MSC BUS-SH T	8.480	5.550	5.490	14.000	-1.920	3.700	7.160	8.860	4.730	6.270
t-test vs 0	*5.320*	*0.020*	*4.530*	*6.150*	*-0.002*	*5.020*	*6.810*	*0.020*	*2.600*	*2.930*
L(max)	***-2340.07***	***-2295.62***			***-2235.86***			***-2106.64***		
No. of parameters	*22*	*44*			*57*			*68*		
L(max)/Sample	*-0.64*	*-0.63*			*-0.61*			*-0.58*		

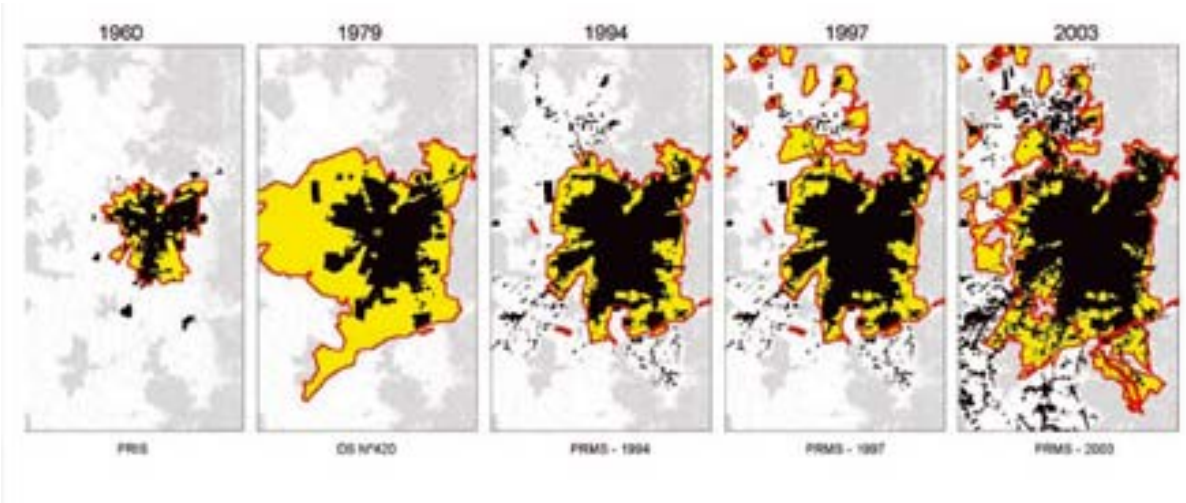
Shock effect

	CD	CP	SH T	METRO	BUS	WALK	BIKE	CD-METRO	CP-METRO	SH T-METRO	BUS-METRO	BUS-SH T
SCHOCK EFFECT(mean)	0.056	-0.065	0.118	-0.635	-0.370	-1.110	-0.077	-0.524	-0.795	-0.772	-0.664	-0.810
t-test vs 0	*2.380*	*-2.400*	*1.820*	*-11.160*	*-2.540*	*-9.670*	*-2.350*	*-5.530*	*-17.210*	*-20.000*	*-15.130*	*-14.690*
SCHOCK EFFECT(st.dev)	0.060	0.560	0.016	0.125	0.041	0.409	0.147	0.029	0.018	0.055	0.070	0.033
t-test vs 0	*2.670*	*3.450*	*2.240*	*-2.920*	*-1.980*	*-2.540*	*1.970*	*-2.350*	*-2.320*	*1.970*	*2.690*	*1.910*

Santiago

Inhabitants: 6 million

Surface: 1,400 m^2



Number of buses: 8000 (380 routes)

Trips in a working day: 16.3 million (10 million by motorised transport modes)

Hypotheses

- Individuals maximize their net utility
- The responses of each individual present panel correlation.
- An intervention, like a radical innovation may generate a shock effect → modifying the choice process → causing changes in utility functions.
- The shock effect could be different for each alternative.
- The shock effect varies among the individuals.

Model Estimation

- ML (Mixed Logit) probability is the integral of standard Logit probabilities over a density of parameters (Train, 2003)
- ML panel probability is the product of ML probabilities:

$$P_{iq}(\mu) = \sum_{w=1}^{W} \int \left(\frac{\exp\left(V_{iq}^{w}\left(\mu_i^{w}\right)\right)}{\sum_{l \in A_q^w} \exp\left(V_{lq}^{w}\left(\mu_i^{w}\right)\right)} \right) \cdot f\left(\mu_i^{w} \middle| \Omega\right) d\mu$$

It is necessary to compute multidimensional integrals for each individual. Therefore, this calculation requires simulate values

$$SP_{iq}^{N} = \frac{1}{N} \sum_{n=1}^{N} \left(\frac{\exp\left(V_{iq}^{w}\left(\mu_i^{w}\right)\right)}{\sum_{l \in A_q^w} \exp\left(V_{lq}^{w}\left(\mu_i^{w}\right)\right)} \right)$$

	Model 4		
	Wave 1	**Wave 2**	**Wave 3**
Number of cars	1.61		
t-test vs 0	*6.93*		
CW (mean)	-0.042		
t-test vs 0	*-7.07*		
CW (st.dev.)	0.024		
t-test vs 0	*-4.35*		
TRAVEL	-0.101		
t-test vs 0	*-6.2*		
WAITING	-0.311		
t-test vs 0	*-8.77*		
WALKING	-0.182		
t-test vs 0	*-11.45*		
INTERCHANGES	-0.673		
t-test vs 0	*-0.99*		
COMFORT (mean)	6.48		
t-test vs 0	*5.58*		
COMFORT (st.dev.)	0.336		
t-test vs 0	*3.44*		
TRANSANT	9.47		
t-test vs 0	*5.66*		
ASC CD	5.17	9.97	11.2
t-test vs 0	*2.34*	*5.71*	*5.34*
ASC CP	4.52	9.55	10.3
t-test vs 0	*2.03*	*5.41*	*4.88*
ASC SH T	6.71	13.2	13.7
t-test vs 0	*3.11*	*6.99*	*6.35*
ASC METRO	8.55	8.09	8.99
t-test vs 0	*3.91*	*4.63*	*4.35*

	Model 4		
	Wave 1	**Wave 2**	**Wave 3**
ASC WALK	7.8	9.34	11.3
t-test vs 0	*3.52*	*5.21*	*5.3*
ASC BIKE	3.72	8.44	11.1
t-test vs 0	*1.67*	*4.7*	*5.15*
ASC CD-METRO	5.87	3.64	6.96
t-test vs 0	*2.61*	*1.99*	*3.49*
ASC CP-METRO	7.24	5.4	6.47
t-test vs 0	*3.31*	*3.21*	*3.21*
ASC SH T-METRO	9.18	6.11	7.12
t-test vs 0	*4.2*	*3.65*	*3.54*
ASC BUS-METRO	8.98	7.09	8.62
t-test vs 0	*4.11*	*4.29*	*4.37*
ASC BUS-SH T	8.86	4.73	6.27
t-test vs 0	*0.02*	*2.6*	*2.93*
L(max)	***-2106.64***		
No. of observations	*3659*		
No. of parameters	*68*		
L(max)/Sample	*-0.58*		

Shock effect

	CD	CP	SH T	METRO	BUS	WALK	BIKE	CD-METRO	CP-METRO	SH T-METRO	BUS-METRO	BUS-SH T
SCHOCK EFFECT(mean)	0.056	-0.065	0.118	-0.635	-0.370	-1.110	-0.077	-0.524	-0.795	-0.772	-0.664	-0.810
t-test vs 0	*2.380*	*-2.400*	*1.820*	*-11.160*	*-2.540*	*-9.670*	*-2.350*	*-5.530*	*-17.210*	*-20.000*	*-15.130*	*-14.690*
SCHOCK EFFECT(st.dev)	0.060	0.560	0.016	0.125	0.041	0.409	0.147	0.029	0.018	0.055	0.070	0.033
t-test vs 0	*2.670*	*3.450*	*2.240*	*-2.920*	*-1.980*	*-2.540*	*1.970*	*-2.350*	*-2.320*	*1.970*	*2.690*	*1.910*