Dynamic Travel Behaviour:

Findings of a stated adaptation experiment and modelling framework

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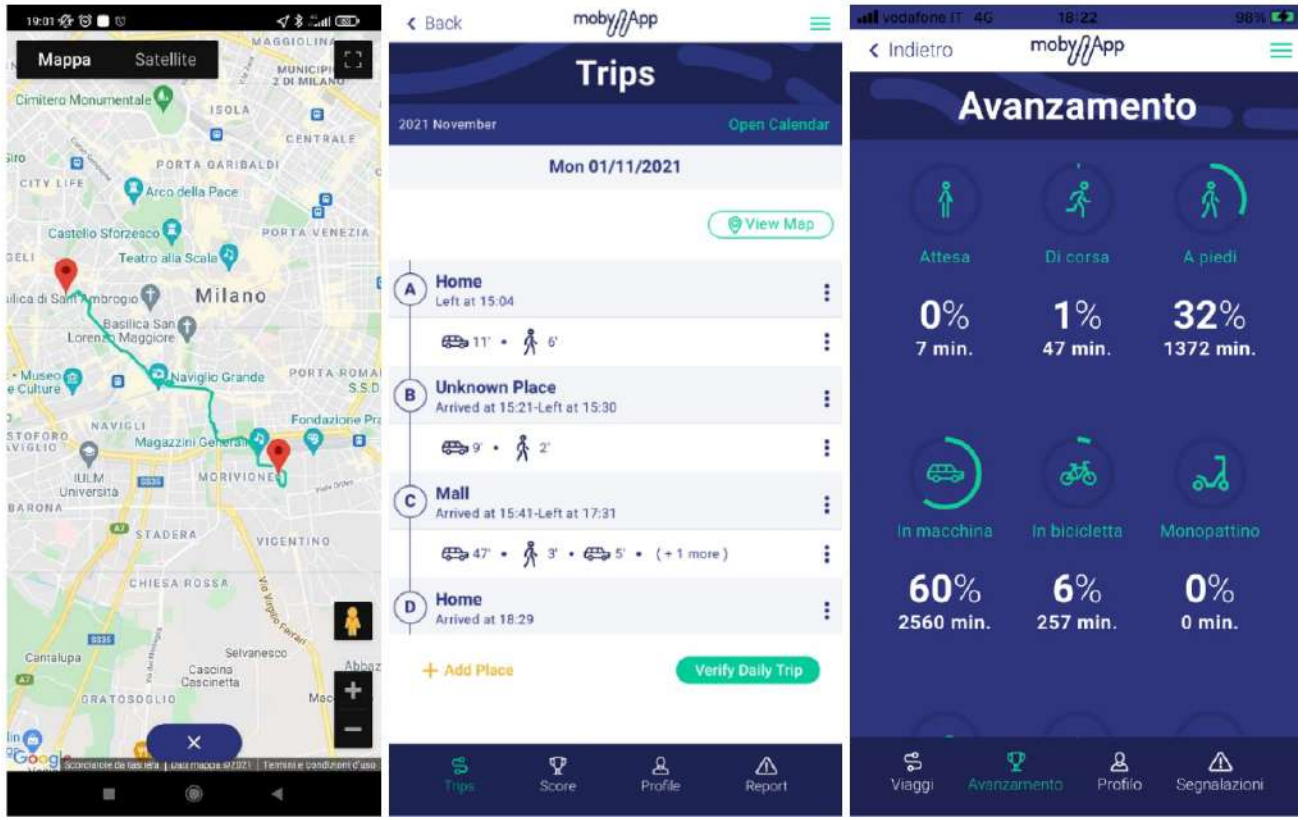
Introduction

Methodology – Data Collection



Moby App (HARMONY project)

Revealed preference

- Habitual activities
- Tracked travel patterns

Stated adaptation

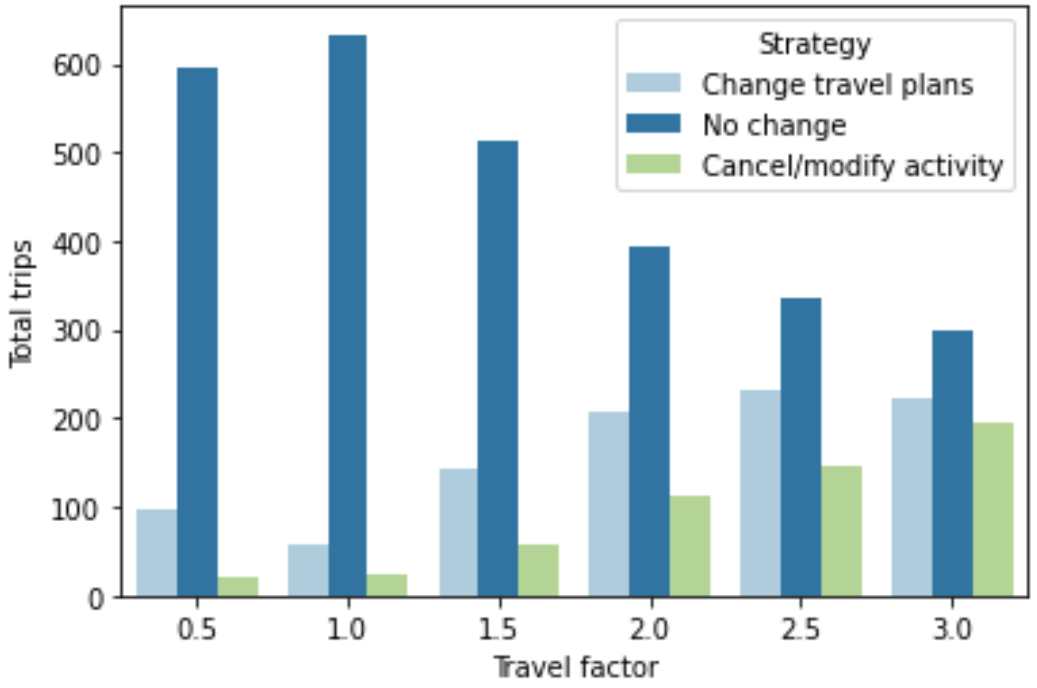
- Within-day re-evaluation
- Day-to-day learning
- Feedback/response quality

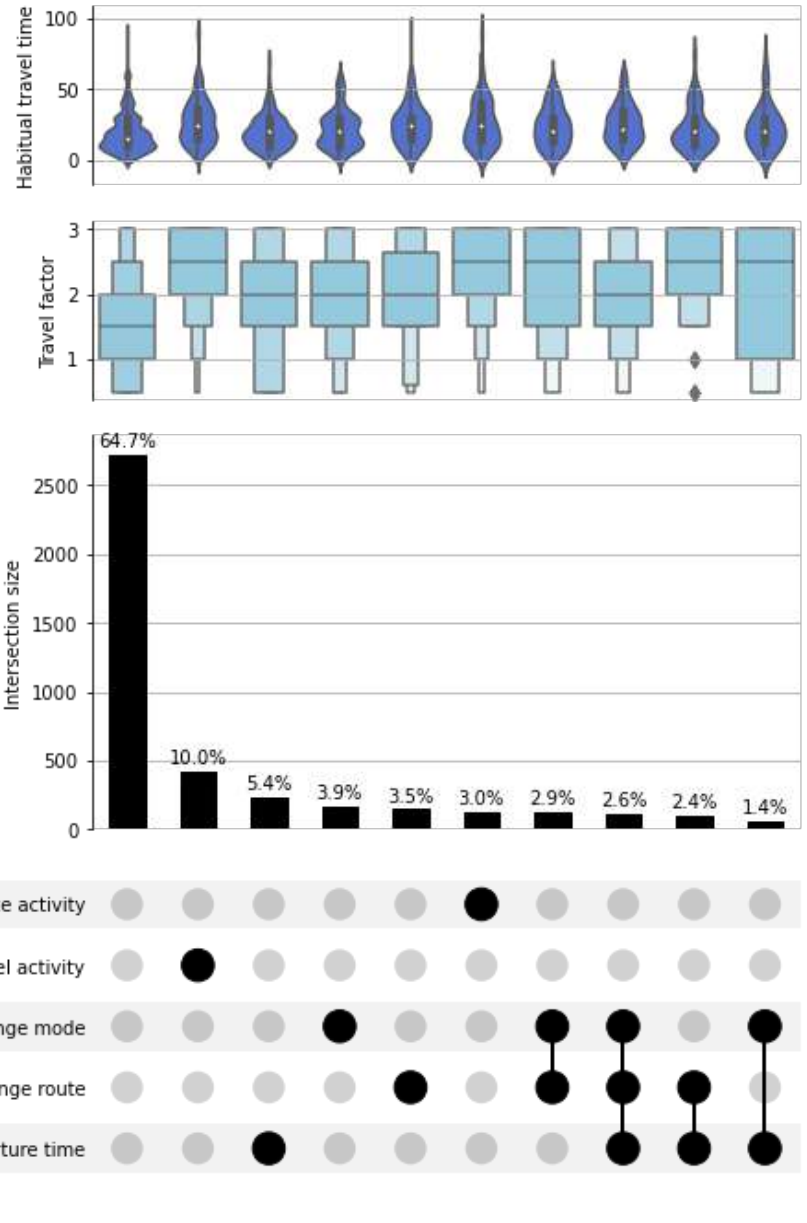
Application

- **Turin**: 351 individuals – 4212 observations
- **Oxfordshire**: 330 individuals – 3960 observations

Exploratory Analysis

Resistance to change, mental effort





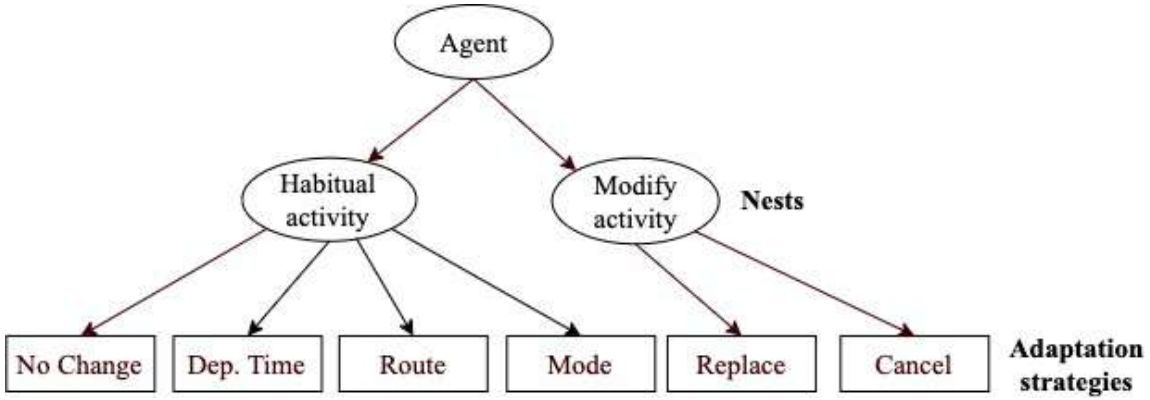
Rational Expectation – Dynamic Hybrid Choice Model

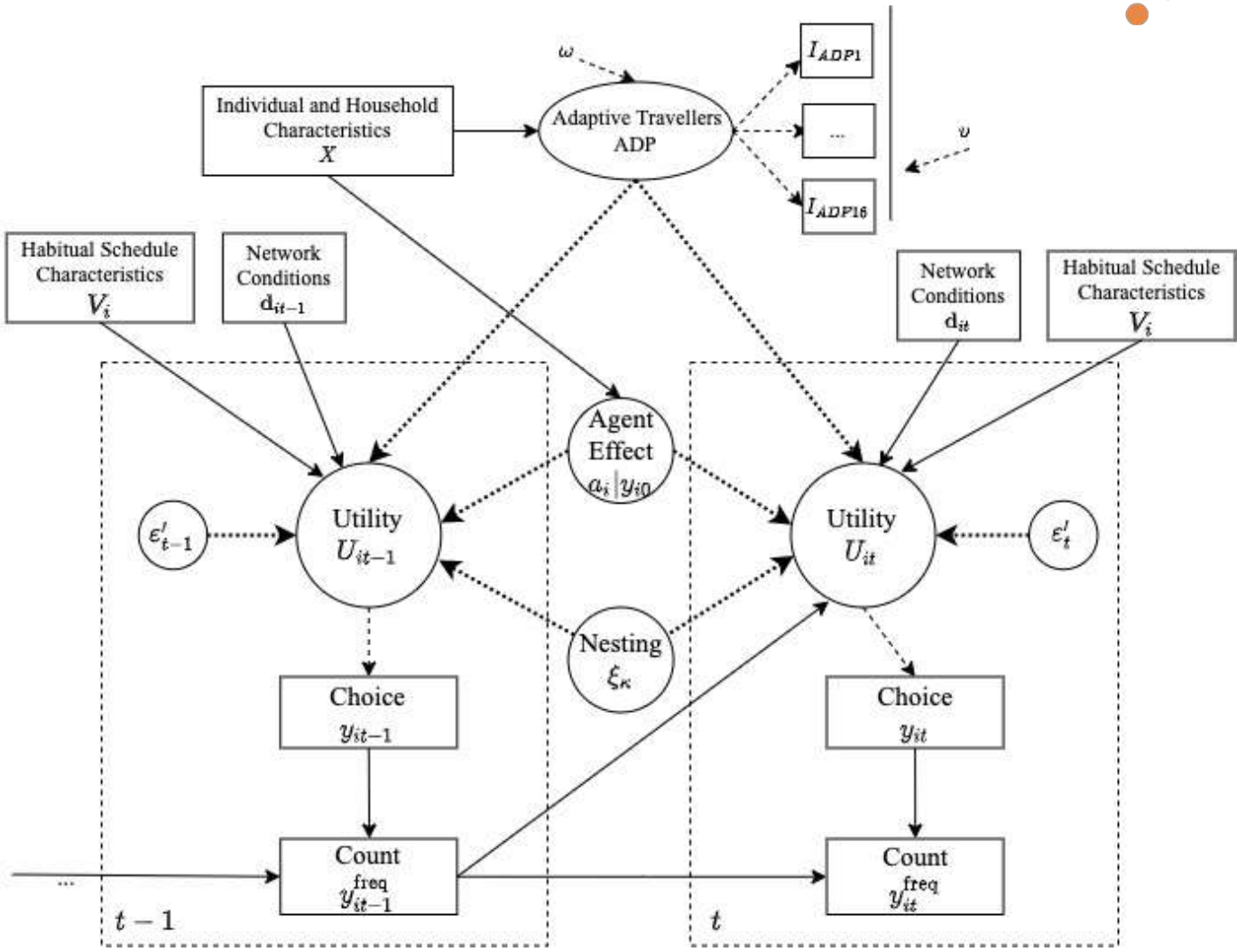
Travel demand shift under information provision

- Pandas Biogeme (Bierlaire)

Significant factors

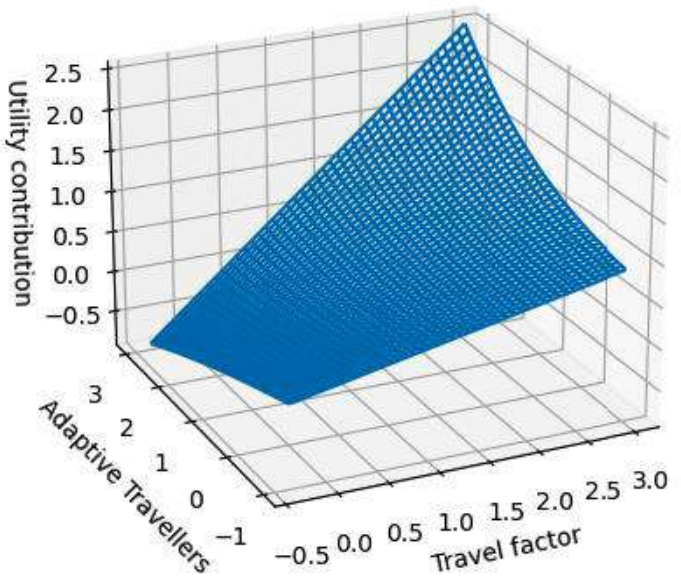
- Past actions and experience
- Travel time fluctuation
- Number of opportunities
- Activity type characteristics



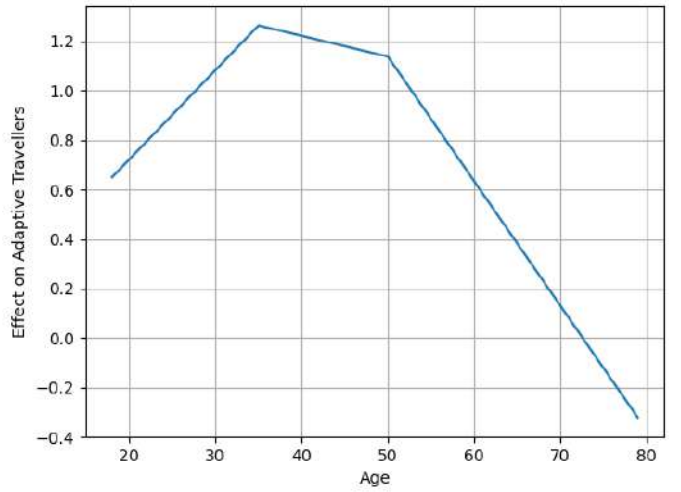


Latent Variable – Adaptive Travellers

Indicators of Adaptive Travellers		Mean	SD
I_{ADP1}	It is very important for me to have short travel time to my main activities	5.76	1.33
I_{ADP2}	I am willing to depart earlier or later if it can reduce my travel time	4.95	1.66
I_{ADP3}	I would like to have flexible working hours to avoid rush hour commute	5.38	1.53
I_{ADP4}	I would like to have remote work options to avoid rush hour commute	4.97	1.89
I_{ADP5}	I would prefer working from home instead of commuting	4.72	1.97
I_{ADP6}	I acquire travel information from my phone, as I am sure of their reliability	4.67	1.50
I_{ADP7}	I acquire travel information from my phone when I go somewhere I have never been before	5.35	1.50
I_{ADP8}	I would acquire travel information from my phone if I come across congestion on my route	5.40	1.50
I_{ADP9}	I am willing to acquire travel information while en-route to my destination	5.39	1.53
I_{ADP10}	I acquire travel information from mobile devices prior to my trip	5.09	1.64
I_{ADP11}	I would feel lost if I run out of battery while travelling	5.00	1.76
I_{ADP12}	When I encounter delays in my travel plans, it stresses me out	4.96	1.60
I_{ADP13}	I always try to maximize the efficiency of my trips	5.96	1.28
I_{ADP14}	Whenever I need to adapt my trip schedule, I try to imagine all potential options	5.17	1.40
I_{ADP15}	I always try to choose what I consider the best mode for my trips	5.51	1.40
I_{ADP16}	I always try to optimize the route I choose for my trips	5.63	1.33



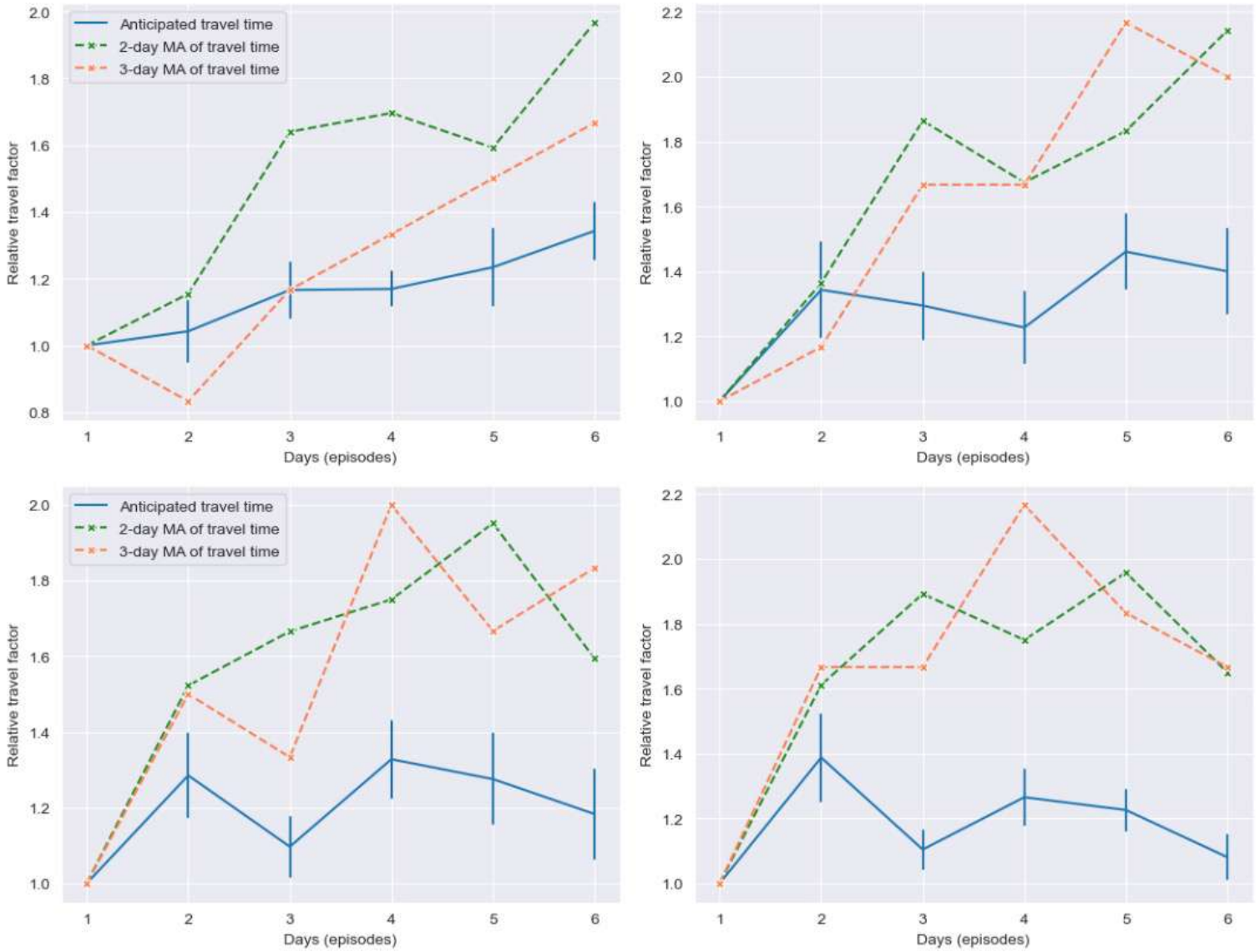
Parameter	Value	t-test
λ_{MALE}	-0.24	-5.7
$\lambda_{AGE\_UNDER35}$	0.0361	6.14
$\lambda_{AGE\_35\text{-}50}$	-0.00839	-2.06
λ_{AGE_OVER50}	-0.0503	-6.81
$\lambda_{HIGHEREDU}$	0.415	6.3
$\lambda_{LICENCE}$	0.287	6.18
$\lambda_{PUBTRAN}$	0.303	3.82



Rational inattention - Motivation

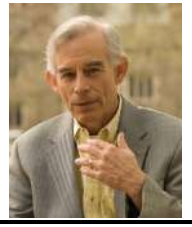
Day-to-day learning

- Resistance to change, inertia
- Sluggishness in response
- Prior ‘magnet effect’



Rational Inattention

Problem Formulation (Sims, Matejka, et al.)



Objective function: $\max_f \int U(y,x) f(y,x) dx dy - C(f)$

Bayesian rationality: $\text{subject to } \int f(y,x) dy = g(x), \ \forall x$

Cost of information: $C(f) = \lambda \cdot I(y;x) = \lambda \cdot [H[g(x)] - E[H[x|y]]$

Entropy measurement: $H[g(x)] = -\int g(x) log\ g(x) dx$

General solution:

$$\text{Continuous choice} \rightarrow f(y|x) = \frac{p(y) e^{U(y,x)/\lambda}}{\int_z p(z) e^{U(z,x)/\lambda} dz}$$

$$\text{Discrete choice} \rightarrow P(i|x) = \frac{e^{\frac{U(i,x)+a(i)}{\lambda}}}{\sum_{j=1}^{N} e^{\frac{U(j,x)+a(j)}{\lambda}}}$$

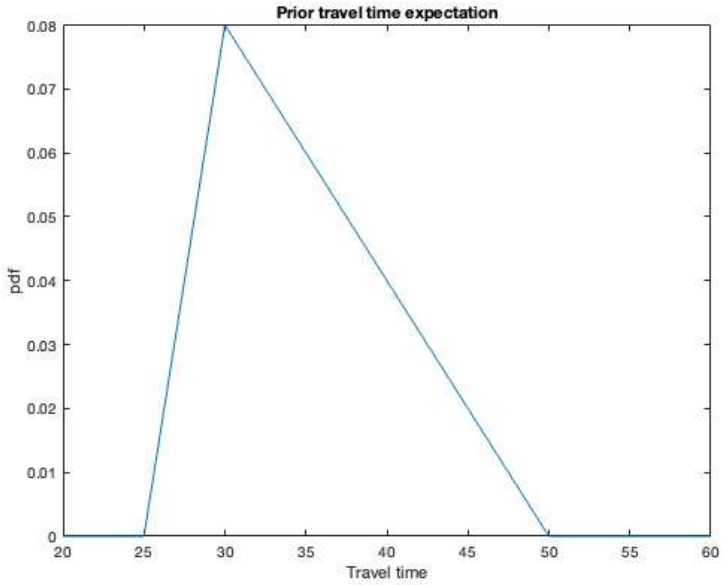
Travel time anticipation

$$U(y,x) = -b(y-x)^2$$

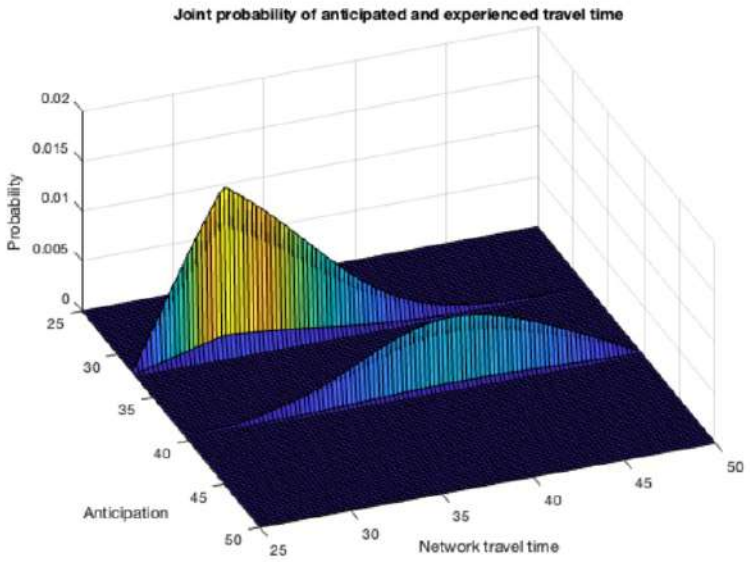
RI $\rightarrow$ $f(y|x)$ chosen optimally

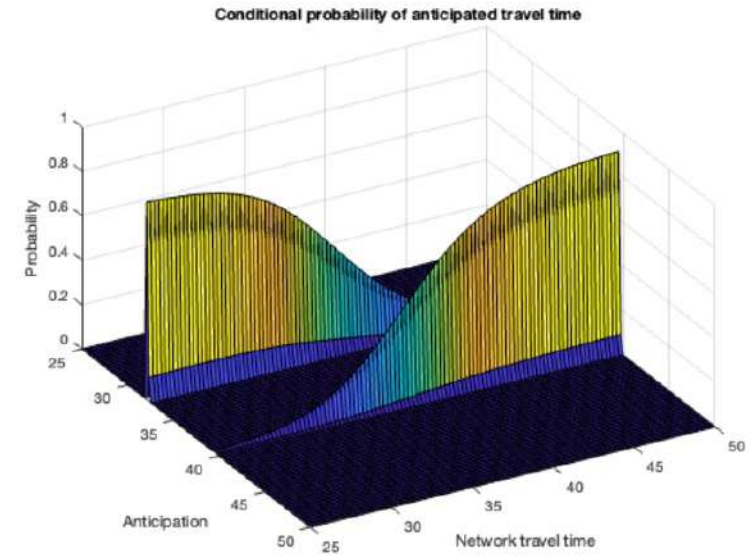
perfect information $\rightarrow$ $y = x$

no information $\rightarrow$ $y = E[g(x)]$

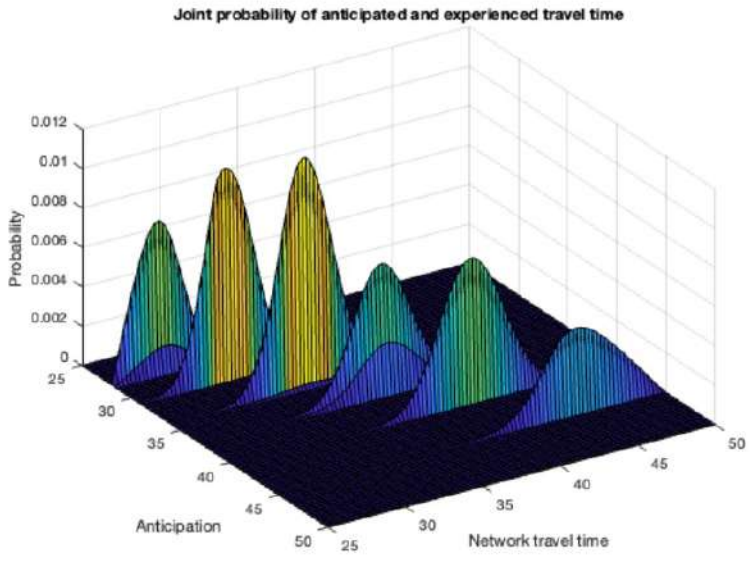


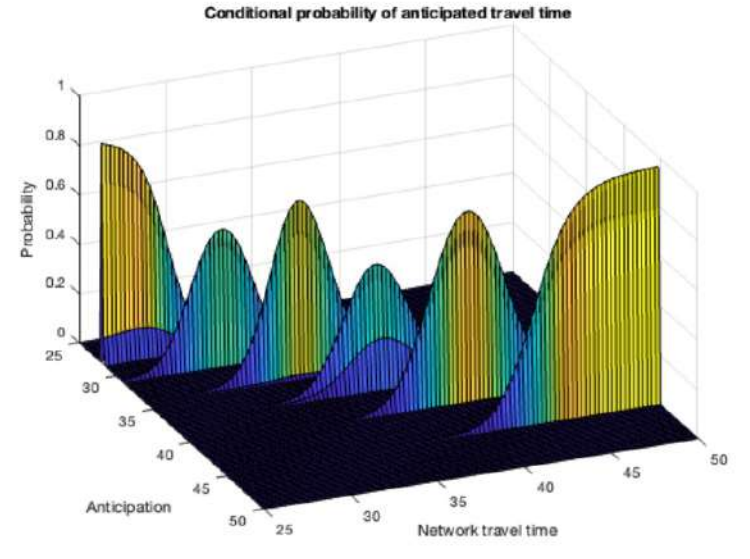
λ = 0.03

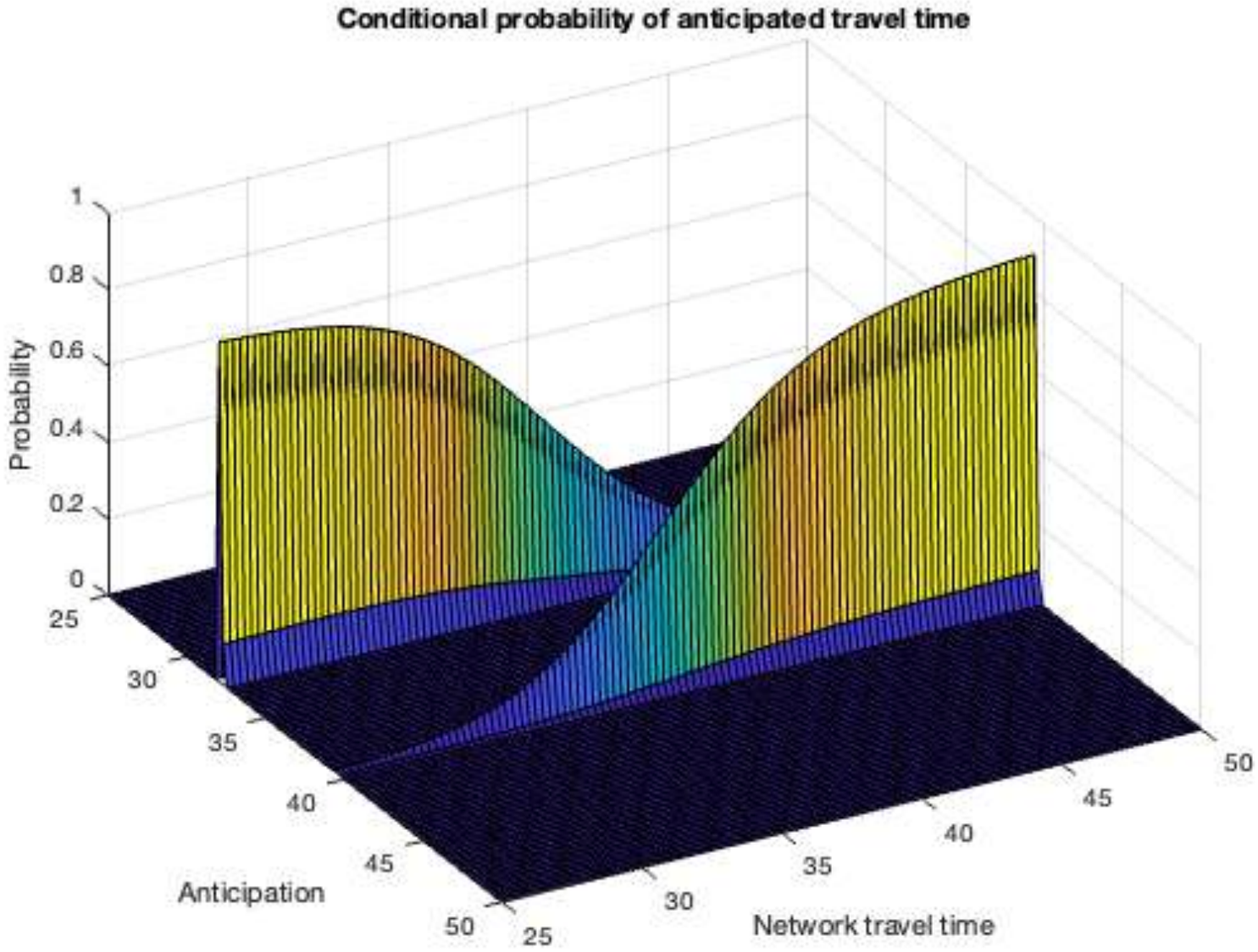




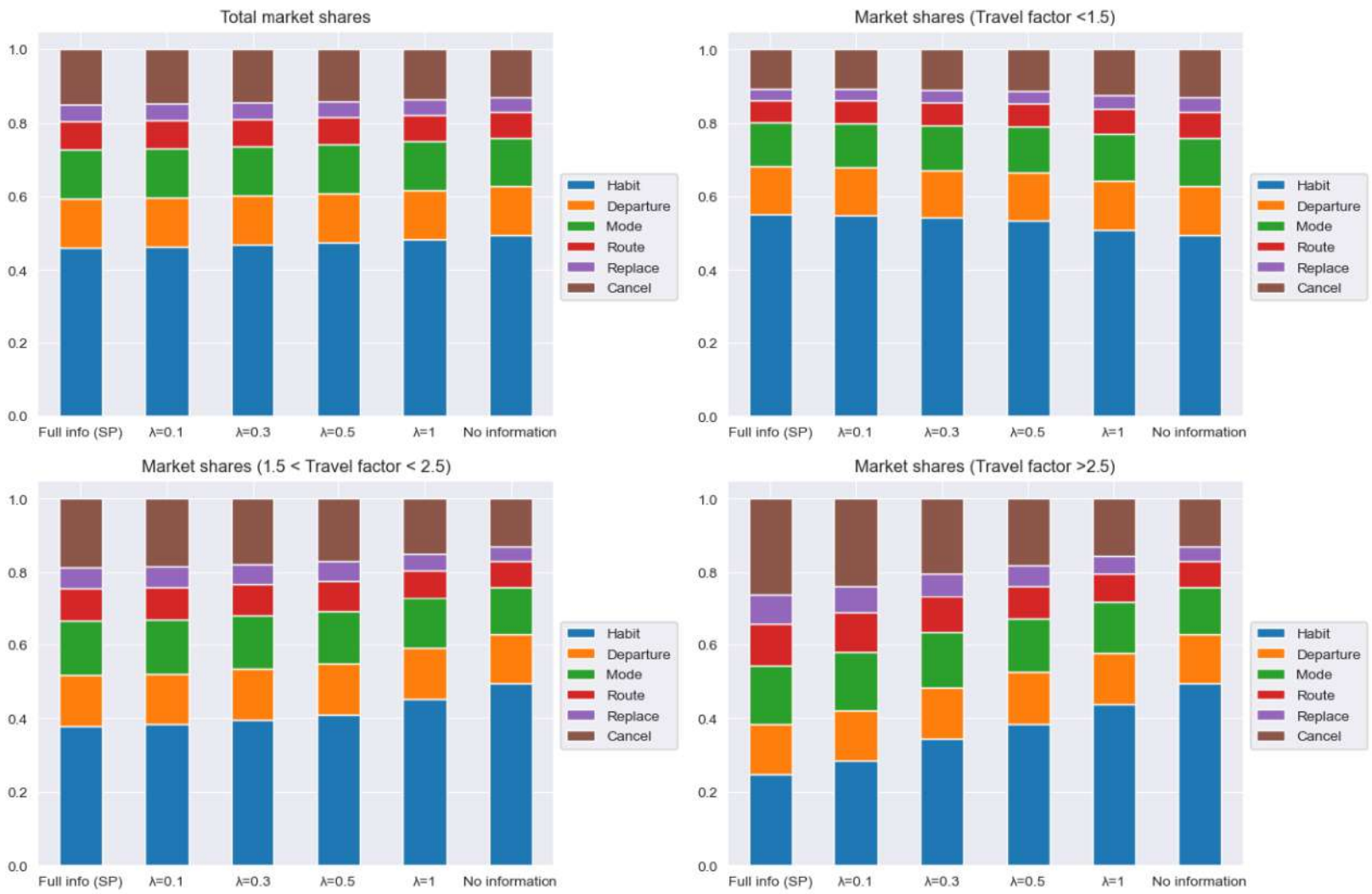
λ = 0.005






Conditional probability of anticipated travel time
Probability
1
0.8
0.6
0.4
0.2
0
25
30
35
40
45
50
Anticipation
25
30
35
40
45
50
Network travel time

Empirical effect



- Market share simulation with or without travel time inattention
- Discrepancy in prediction, especially for rare occurrences of the travel time distribution
- Underreaction but also overreaction ‘mistakes’
- Importance of quantifying the information cost

Future Work

1. Integration of dynamic demand shift model in within-day simulation

- Increased realism, personalization for menu set generation

2. Further exploration of RI in transportation phenomena

- Few studies with mostly theoretical contributions (Fosgerau)
- Forward-looking dynamic extensions

3. Data collection-estimation

- Joint measurement of belief, world, attention (signal), action
- Implications of general equivalence with RUM (Fosgerau)

4. Insights from observational / RP data

- What are we actually capturing? More than preferences?
- How to separate utility and priors/information cost?
- Market shares could be used as the priors (Caplin, Habib)

5. Application in other demand/supply models within transportation

- Travel information provision, adaptive ticket/toll pricing, service frequency

Conclusion

"In an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."

Herbert A. Simon (Nobel Laureate 1978)

Thank you!

	Static						Dynamic *(frequency)*					
	Multinomial Logit		Mixed Multinomial Logit		Mixed Nested Logit		Multinomial Logit		Mixed Multinomial Logit		Mixed Nested Logit	
Parameter	Value	t-test	Value	t-test	Value	t-test	Value	t-test	Value	t-test	Value	t-test
$ASC_{DEPARTURETIME}$	-1.83	-14.5	-2.72	-12.7	-3.25	-9.97	-2	-13.9	-2.16	-11	-2.13	-10.8
ASC_{MODE}	-2.1	-19.8	-2.63	-13.7	-3.78	-14.3	-2.45	-19.2	-2.5	-17.4	-2.49	-17.4
ASC_{ROUTE}	-3.14	-21.2	-3.3	-18.7	-3.71	-16.8	-3.1	-19.2	-3.17	-18.1	-3.16	-18.1
$ASC_{REPLACE}$	-4.11	-19.2	1.05	4.12	-6.15	-13.9	-4.07	-17.	-4.74	-12.4	-4.87	-12.4
ASC_{CANCEL}	-2.32	-19	-3.91	-12.3	-4.63	-14.2	-2.86	-18.8	-3.72	-13.5	-3.81	-13.4
$ASC_{NOCHANGE}$	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
$\beta_{WORK,NOCHANGE}$	-0.579	-6.89	-0.571	-5.91	-0.776	-4.17	-0.391	-4.25	-0.432	-4.16	-0.418	-4.12
$\beta_{WORK,CANCEL}$	-1.09	-7.36	-1.14	-5.69	-1.57	-4.56	-0.728	-4.52	-1.08	-4.23	-1.04	-4.05
$\beta_{BASETIME,NOCHANGE}$	-0.582	-12	-0.621	-9.89	-0.853	-7.73	-0.433	-8.31	-0.485	-7.46	-0.469	-7.32
$\beta_{ALT,MODES,MODE}$	0.152	6.31	0.14	5.08	0.279	4.3	0.0869	3.15	0.0985	3.39	0.351	3.38
$\beta_{ALT,ROUTES,ROUTE}$	0.354	7.05	0.422	7.26	0.417	5.67	0.284	5.09	0.29	5.02	0.293	13.6
$\beta_{ALT,DESTIN,REPLACE}$	0.356	6.26	0.355	6.17	0.459	4.15	0.283	4.68	0.349	4.27	0.351	4.24
$\beta_{TIMEDIFF,DEPARTURETIME}$	0.701	7.67	0.636	6.11	0.998	8.27	0.829	8.26	0.857	8.06	0.844	7.97
$\beta_{TIMEDIFF,MODE}$	0.809	12.4	1.05	12.5	1.26	14.5	1.08	14.4	1.1	13.7	1.09	13.6
$\beta_{TIMEDIFF,ROUTE}$	1.09	12.2	1.05	11.6	1.43	13.8	1.23	12.8	1.25	12.4	1.23	12.3
$\beta_{TIMEDIFF,REPLACE}$	1.36	10.3	1.45	10.2	1.97	12	1.6	11.5	1.68	11	1.76	11.1
$\beta_{TIMEDIFF,CANCEL}$	1.31	17.1	1.77	16.2	2.16	18.5	1.69	19.1	1.94	17.5	1.97	17.4
$\rho_{FREQ,TRAVEL}$	0.0	-	0.0	-	0.0	-	1.25	26.5	1.19	21.1	1.2	21.2
$\rho_{FREQ,ACTIV}$	0.0	-	0.0	-	0.0	-	1.26	19.1	0.639	4.88	0.628	4.77
$\rho_{FREQ,NOCHANGE}$	0.0	-	0.0	-	0.0	-	0.4	13.1	0.352	9.49	0.355	9.66
$\sigma_{DEPARTURETIME}$	0.0	-	-1.18	-5.39	-2.44	-8.53	0.0	-	0.519	1.72	0.475	1.4*
σ_{MODE}	0.0	-	1.86	8.02	2.13	12.5	0.0	-	0.0073	0.041*	0.0023	0.013*
σ_{ROUTE}	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
$\sigma_{REPLACE}$	0.0	-	1.05	4.12	1.4	4.3	0.0	-	1.14	4.57	0.782	2.19
σ_{CANCEL}	0.0	-	2.77	11.2	2.19	8.99	0.0	-	0.519	6.87	1.35	4.87
$\sigma_{NOCHANGE}$	0.0	-	0.515	3.03	1.47	13.8	0.0	-	0.398	2.4	0.323	1.64*
σ_{MODIFY}	0.0	-	0.0	-	1.38	4.98	0.0	-	0.0	-	1	4.34
σ_{HABIT}	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
Nb of observations	4212											
L(0)	-7173.496											
Nb. of parameters	16		21		22		19		24		25	
AIC	8754.114		8169.515		7536.669		7348.235		7328.241		7325.476	
L(β)	-4361.057		-4063.57		-3746.335		-3655.118		-3640.12		-3637.738	
Likelihood ratio test (within)	594.974(>11.07)		634.47(>3.84)				29.996(>11.07)		4.764(>3.84)			
Likelihood ratio test (across)	1411.878(>7.81)		846.9(>7.81)		217.194(>7.81)							