Context-dependent models comparisons

Swiss and German SP, RP data sets

Author(s):
Belgiawan, Prawira F.; Dubernet, Ilka; Schmid, Basil; Axhausen, Kay W.

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Context-dependent models comparisons: Swiss and German SP, RP data sets

Prawira Fajarindra Belgiawan
Ilka Dubernet
Basil Schmid
Kay W. Axhausen

IVT ETH Zürich

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Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Introduction

- Recently there is a growing interest in implementing an alternative approach called Random Regret Minimization (RRM) (Chorus et al., 2008; Chorus, 2010)

- In RRM, an individual when choosing between alternatives is assumed to minimize anticipated regret as opposed to maximizing his/her utility ➔ context dependent modelling

- Context-dependent modeling approaches
  - CRRM – ‘classic’ random regret minimization
  - μRRM – scaled random regret minimization
  - PRRM – Pure random regret minimization
  - RAM – Relative advantage maximization

Objectives

- There have been many attempts that compare the performance of RRMs compare to RUM
  - Model fit : From 43 cases, 15 cases RUM better, 15 cases RRM better, and 13 cases neither (Chorus et al. 2014)
  - VTTS :There is a small and statistically significant difference between RUM, RRM and RAM (Leong and Hensher, 2015)
  - Elasticities : RRM elasticities are 10% greater compared to RUM (Chorus and Bierlaire, 2013; Thiene et al., 2012))

- Objective of this study to compare RUM, RRMs, and RAM comprehensively in term of
  - model fit,
  - prediction accuracy,
  - VTTS, and
  - demand elasticities

Model formulations: CRRM (Chorus, 2010)

Random regret

$$RR_{iq} = R_{iq} + \varepsilon_{iq} = \alpha_i + \sum_{j \neq i} \sum_k \ln\left(1 + \exp\left[\beta_k \cdot \left(X_{kjq} - X_{kiq}\right)\right]\right) + \varepsilon_{iq}$$

Probabilities

$$P_{iq} = \frac{\exp\left(-R_{iq}\right)}{\sum_{\substack{i \in J \\ j=1}}^{J} \exp\left(-R_{jq}\right)}$$

Model formulations: µRRM (Van Cranenburgh et al. 2015)

µ Random regret

$$RR_{iq}^{\mu\mathrm{RRM}} = \alpha_i + R_{iq}^{\mu\mathrm{RRM}} + \varepsilon_{iq} = \alpha_i + \sum_{j \neq i} \sum_{k} \ln\left(1 + \exp\left[\frac{\beta_k}{\mu} \cdot \left(X_{kjq} - X_{kiq}\right)\right]\right) + \varepsilon_{iq}$$

Probabilities

$$P_{iq}^{\mu RRM} = \frac{\exp\left(-\mu R_{iq}^{\mu RRM}\right)}{\sum_{\substack{i \in J \\ j=1}}^{J} \exp\left(-\mu R_{jq}^{\mu RRM}\right)}$$

Model formulations: PRRM (Van Cranenburgh et al. 2015)

P Random regret

$$R_{iq}^{P-RRM} = \alpha_i + \sum_k \beta_k X_{kjiq}^{P-RRM} \quad \text{where } X_{kjiq}^{P-RRM} = \begin{cases} \sum_{j \neq i} \max\left(0, X_{kjq} - X_{kiq}\right) \text{ if } \beta_k > 0 \\ \sum_{j \neq i} \min\left(0, X_{kjq} - X_{kiq}\right) \text{ if } \beta_k < 0 \end{cases}$$

Probabilities

$$P_{iq} = \frac{\exp\left(-R_{iq}\right)}{\sum_{\substack{i \in J \\ j=1}}^{J} \exp\left(-R_{jq}\right)}$$

Model formulations: RAM (Leong and Hensher, 2015)

Disadvantage/Advantage

$$A_{kijq} = D_{kjiq} = \ln\left(1 + \exp\left[\beta_k \cdot \left(X_{kiq} - X_{kjq}\right)\right]\right)$$

$$A_{ijq} = \sum_k A_{kijq} \quad \text{and} \quad D_{ijq} = \sum_k D_{kijq}$$

Relative advantage

$$RA_{ijq} = \frac{A_{ijq}}{A_{ijq} + D_{ijq}}$$

Utility function

$$V_{iq}^{RAM} = \alpha_i + \sum_{k'} \beta_{k'} X_{k'iq} + \sum_{\substack{i \in J \\ j \neq i}} RA_{ijq}$$

IVT data sets used (Swiss residents)

Data set	Sample	Obs.	Choice set composition
Swiss Metro	623	5607	Train, Swissmetro, car
Influence of parking (location)	631	6301	Location A, location B, none of these
Influence of parking (parking)	585	5853	Parking A, parking B, none of these
Influence of parking (mode choice)	168	1666	Walk, bike, car, transit
Car-sharing	735	4350	Car-sharing, car, transit
Carpooling	511	3975	Car, carpooling as driver (CPD), carpooling as passenger (CPP), transit
RP mode choice	33942	33942	Walk, bike, car, transit
German VOT	2058	15681	Walk, bike, public transport (including long distance train), coach (long distance), car, plane

Model formulation (special case – missing alternatives)

Carpooling (MNL):

V1 = ASC1 + B_TIME * T1 + B_COST * C1
V2 = ASC2 + B_TIME * T2 + B_COST * C2
V3 = ASC3 + B_TIME * T3 + B_COST * C3
V4 = ASC4 + B_TIME * T4 + B_COST * C4

Carpooling (CRRM):

A2 = (CPD_AV == 1); A3 = (CPP_AV == 1); A4 = (PT_AV == 1)

R1 = ASC1 + A2 * log(1 + exp(B_TIME * (T2 - T1))) + A3 * log(1 + exp(B_TIME * (T3 - T1))) + A4 * log(1 + exp(B_TIME * (T4 - T1))) + A2 * log(1 + exp(B_COST * (C2 - C1))) + A3 * log(1 + exp(B_COST * (C3 - C1))) + A4 * log(1 + exp(B_COST * (C4 - C1)))

R2 = ASC2 + log(1 + exp(B_TIME * (T1 - T2))) + A3 * log(1 + exp(B_TIME * (T3 - T2))) + A4 * log(1 + exp(B_TIME * (T4 - T2))) + log(1 + exp(B_COST * (C1 - C2))) + A3 * log(1 + exp(B_COST * (C3 - C2))) + A4 * log(1 + exp(B_COST * (C4 - C2))))

R3 = ASC3 + log(1 + exp(B_TIME * (T1 - T3))) + A2 * log(1 + exp(B_TIME * (T2 - T3))) + A4 * log(1 + exp(B_TIME * (T4 - T3))) + log(1 + exp(B_COST * (C1 - C3))) + A2 * log(1 + exp(B_COST * (C2 - C3))) + A4 * log(1 + exp(B_COST * (C4 - C3)))

R4 = ASC4 + log(1 + exp(B_TIME * (T1 - T4))) + A2 * log(1 + exp(B_TIME * (T2 - T4))) + A3 * log(1 + exp(B_TIME * (T3 - T4))) + log(1 + exp(B_COST * (C1 - C4))) + A2 * log(1 + exp(B_COST * (C2 - C4))) + A3 * log(1 + exp(B_COST * (C3 - C4)))

Model fit: Final LL

Data set	μ	MNL	CRRM	μRRM	PRRM	RAM
Swiss Metro	1.21	-4382	-4539	-4373	-4418	-4239
Location	6.22	-5064	-4994	-4988	-5011	-5294
Parking	3.34	-3160	-2934	-2930	-2926	-3964
Parking mode choice	1.17	-1359	-1350	-1350	-1349	-1414
Car-sharing	0.12	-3987	-3961	-3939	-3938	-3816
Carpooling	0.09	-3951	-3949	-3929	-3922	-3833
RP mode choice	2.59	-15418	-15411	-15382	-15459	-14991
German VOT	0.24	-12944	-12890	-12873	-12832	-12472

Model fit: μ Test

Data set	MNL	μ = 10	CRRM	μ = 1	PRRM	μ=0.01
Swiss Metro	-4382	-4381	-4539	-4539	-4418	-4609
Location	-5064	-4988	-4994	-4994	-5011	-6748
Parking	-3160	-2930	-2934	-2934	-2926	-5866
Parking mode choice	-1359	-1356	-1350	-1350	-1349	-1352
Car-sharing	-3987	-3984	-3961	-3961	-3938	-3943
Carpooling	-3951	-3951	-3949	-3949	-3922	-3930
RP mode choice	-15418	-15403	-15411	-15411	-15459	-24000
German VOT	-12944	-12926	-12890	-12890	-12832	-13108

Model fit: Hit rate

Data set	MNL	CRRM	µRRM	PRRM	RAM
Swiss Metro	68.50%	68.50%	68.50%	68.50%	69.10%
Location	67.80%	68.00%	68.00%	68.00%	67.30%
Parking	81.10%	81.70%	81.90%	81.30%	80.10%
Parking mode choice	65.49%	61.16%	61.22%	61.34%	62.30%
Car-sharing	59.20%	59.80%	60.00%	60.10%	60.70%
Carpooling	49.26%	49.08%	49.74%	49.74%	51.30%
RP mode choice	87.30%	87.30%	87.30%	87.30%	87.40%
German VOT	63.61%	63.89%	63.84%	64.28%	65.33%

Model fit: Hit rate(2)

Data set	All models predict the same outcome	All models predict the right outcome
Swiss Metro	91.14%	64.38%
Location	94.02%	65.40%
Parking	88.47%	78.01%
Parking mode choice	67.65%	47.84%
Car-sharing	82.76%	52.69%
Carpooling	81.91%	43.00%
RP mode choice	99.48%	87.10%
German VOT	89.64%	60.03%

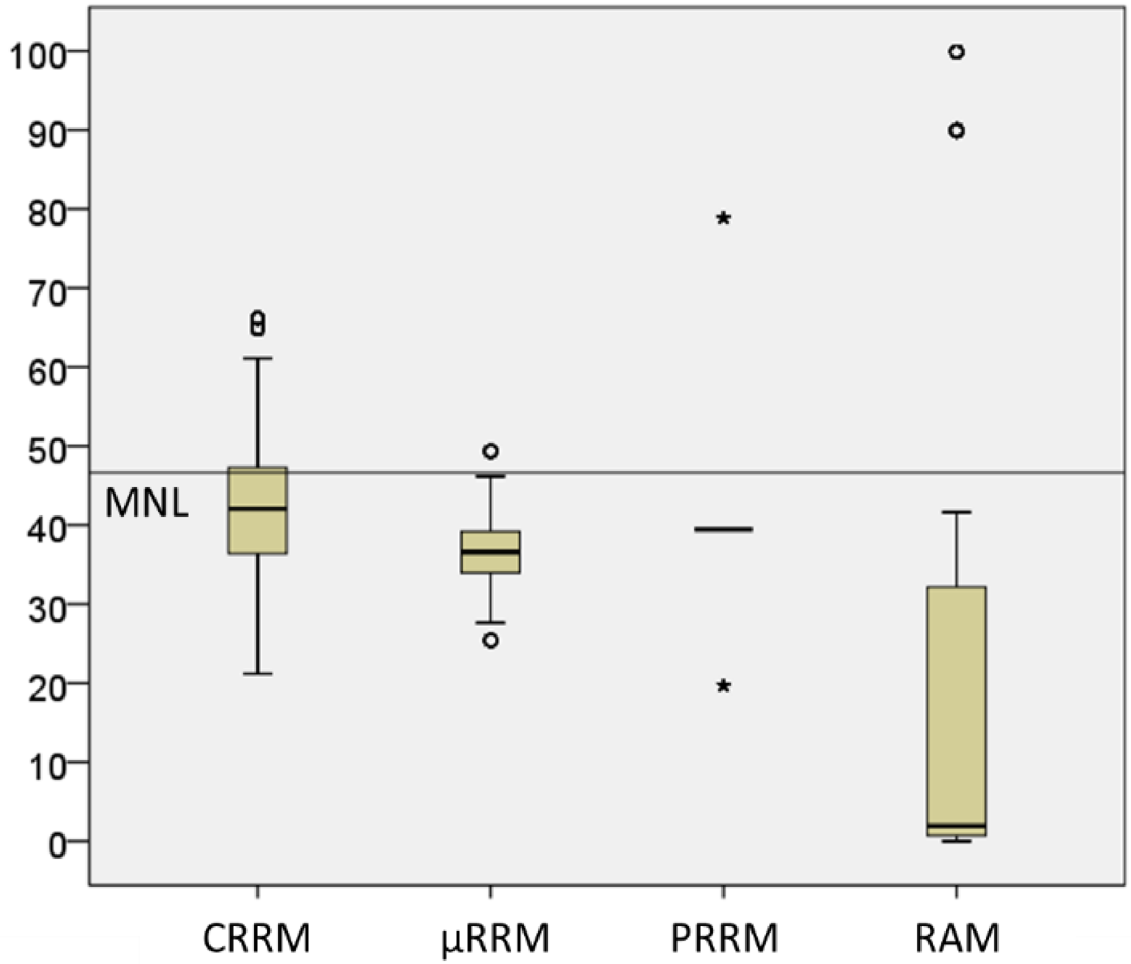
Values of time (mean CHF/hour) (1)

Data set	Mode	MNL	CRRM	μRRM	PRRM	RAM
Swiss Metro	Train	66	151	85	130	39
	Swissmetro		57	49	52	35
	Car		134	79	62	113
Location		20	19	18	22	32
Parking		47	42	37	39	$6*10^{10}$
Parking Mode Choice	Walk	46	105	100	116	17
	Bike		56	55	87	86
	Car		39	39	43	147
	Transit		55	54	64	34
Car-sharing	Car-sharing	105	92	60	96	85
	Car		95	68	94	95
	Transit		159	$9*10^{10}$	175	118

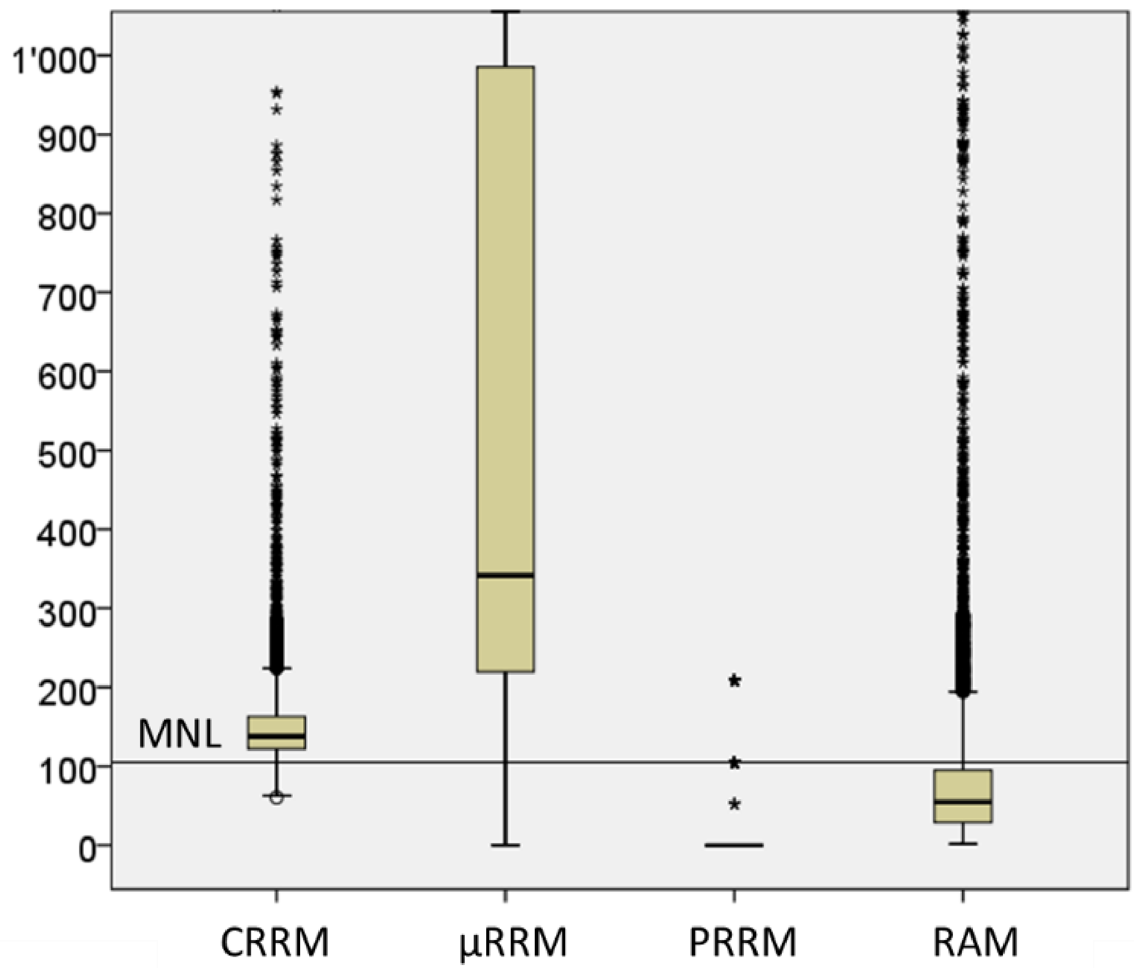
Values of time (mean CHF/hour) (2)

Data set	Mode	MNL	CRRM	µRRM	PRRM	RAM
Carpooling	Car	10	14	19	19	15
	CP as driver		14	55	34	11
	CP as passenger		15	$5*10^5$	30	12
	Transit		14	24	21	41
RP mode choice	Walk	9	19	15	33	2
	Bike		11	11	17	5
	Car		7	9	5	3
	Transit		9	10	6	8
German VOT (€/h)	Walk	140	170	168	225	5
	Bike		141	132	227	10
	PT		138	114	131	18
	Coach		137	112	147	$8*10^5$
	Car		129	105	124	21
	Plane		19	0	83	44

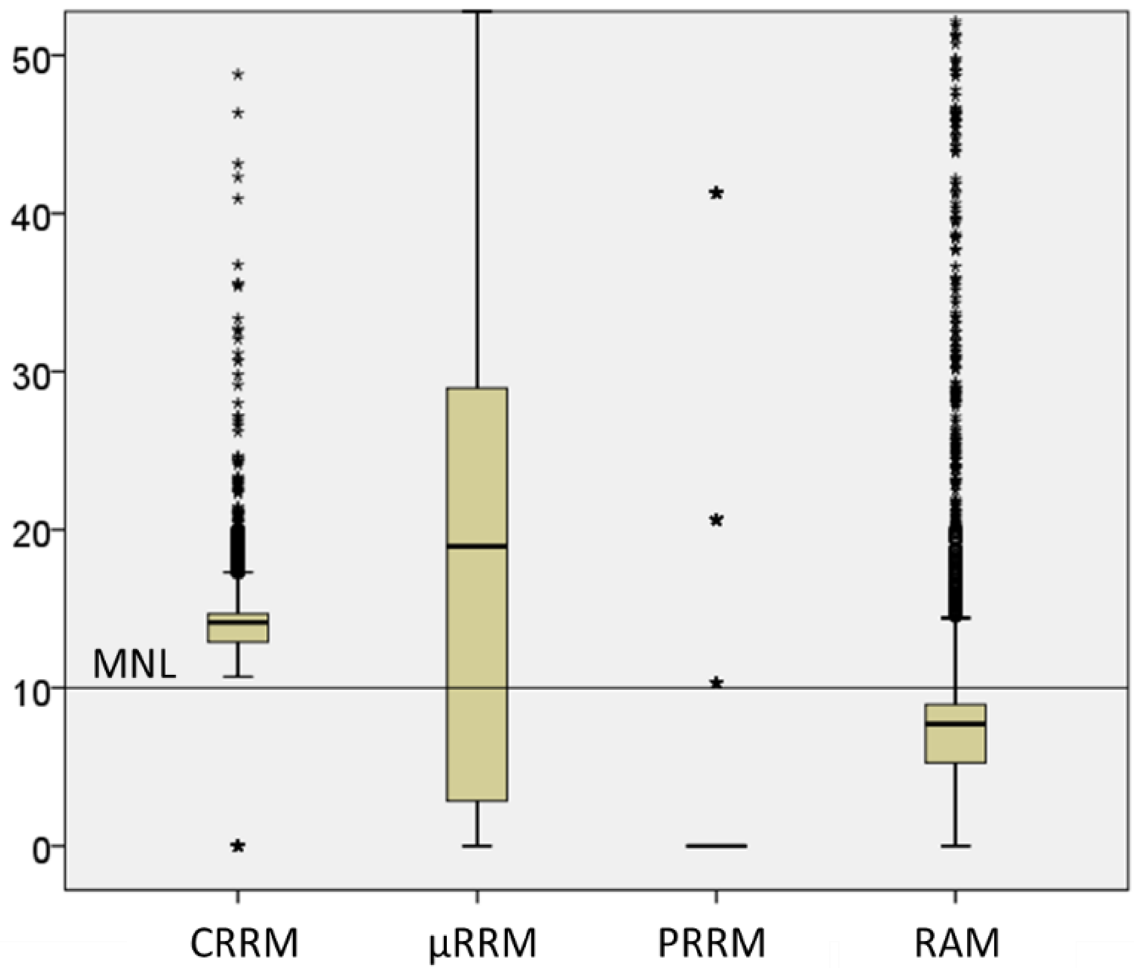
Parking Choice VTTS (CHF/hour)



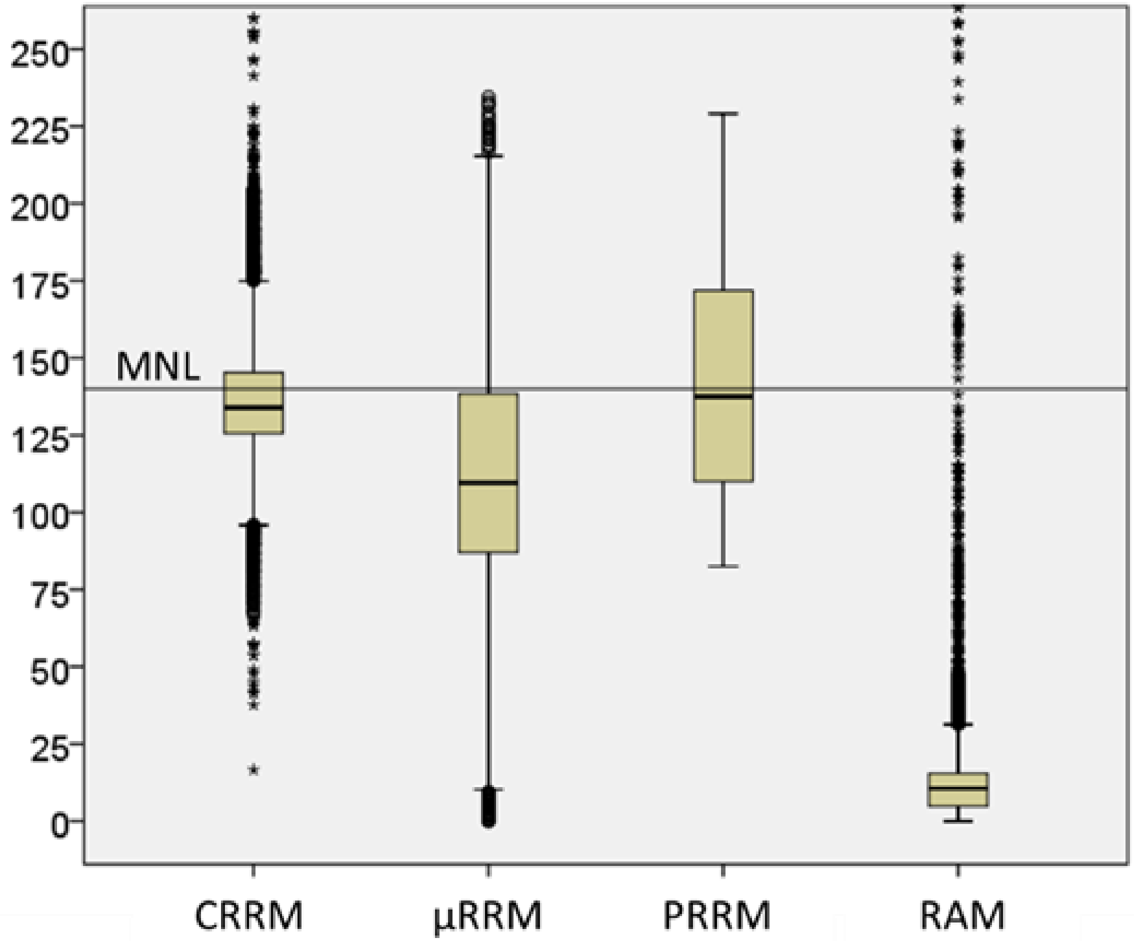
Transit VTTS (CHF/hour) (Car-sharing data set)



Carpooling as passenger (CHF/hour)



German VOT coach alternative (Euro/hour)



Elasticities: Travel time – Car, where applicable

Data set	MNL	CRRM	µRRM	PRRM	RAM
Swiss Metro	-1.37	-2.55	-1.21	-2.56	-1.00
Location	-1.13	-1.23	-0.19	-1.60	-0.55
Parking	-1.88	-2.54	-0.74	-3.43	-0.93
Parking mode choice	-1.34	-1.65	-1.41	-1.92	-0.57
Car-sharing	-0.52	-0.57	-4.51	-0.84	-0.63
Carpooling	-0.19	-0.25	-3.61	-0.51	-0.29
RP mode choice	-0.05	-0.05	-0.02	-0.02	-0.05
German VOT	-0.35	-0.40	-1.64	-1.25	-0.33

Elasticities: Cost – Car, where applicable

Data set	MNL	CRRM	µRRM	PRRM	RAM
Swiss Metro	-0.79	-0.91	-0.69	-1.65	-0.74
Location	-0.57	-0.63	-0.10	-0.77	-0.28
Parking	-0.89	-1.45	-0.46	-1.96	-0.66
Parking mode choice	-0.68	-0.84	-0.72	-1.09	-0.22
Car-sharing	-0.36	-0.42	-3.95	-0.73	-0.49
Carpooling	-0.23	-0.20	-2.23	-0.32	-0.29
RP mode choice	-0.03	-0.03	-0.01	-0.03	-0.06
German VOT	-0.05	-0.02	-0.10	-0.05	-0.24

Summary: Model Fit/Hit rate

Data set	MNL	CRRM	µRRM	PRRM	RAM
Swiss Metro					+/+
Location		/+	+/+	/+	
Parking			/+	+/	
Parking mode choice	/+			+/	
Car-sharing					+/+
Carpooling					+/+
RP mode choice					+/+
German VOT					+/+

Why not Relative Regret Minimization (ReRM)?

Relative disadvantage

$$RER_{ijq} = \frac{D_{ijq}}{A_{ijq} + D_{ijq}}$$

Utility function

$$V_{iq}^{RERM} = \alpha_i + \sum_{k'} \beta_{k'} X_{k'iq} + \sum_{\substack{i \in J \\ j \neq i}} RER_{ijq}$$

Probabilities

$$P_{iq} = \frac{\exp\left(-V_{iq}^{RERM}\right)}{\sum_{\substack{i \in J \\ j=1}}^{J} \exp\left(-V_{iq}^{RERM}\right)}$$

RAM vs ReRM Value of Time

Data set	Mode	RAM	ReRM
Swiss Metro	Train	39	63
	SM	35	63
	Car	113	62
Location		32	46
Parking		$6*10^{10}$	$4*10^{19}$
Parking Mode Choice	Walk	17	17
	Bike	86	86
	Car	147	147
	Transit	34	34
Car-sharing	CS	85	58
	Car	95	58
	Transit	118	58

Data set	Mode	RAM	RAM
Carpooling	Car	15	18
	CPD	11	10
	CPP	12	16
	Transit	41	49
RP mode choice	Walk	2	2
	Bike	5	5
	Car	3	3
	Transit	8	8
German VOT (€/h)	Walk	5	5
	Bike	10	10
	PT	18	18
	Coach	$8*10^5$	$8*10^5$
	Car	21	21
	Plane	44	44

Conclusion

- None of the two approaches, RUM and RRM, are confirmed to be superior in all cases. For labelled data and complete alternatives RAM appears superior

- In many cases, RUM and RRM hit rate is almost similar. Surprisingly the hit rate of RAM model is slightly higher than others especially for labelled data and RP data.

- For VTTS, we found strange cases where in one case the value is too low (in case of RP mode choice) while in other case the value is too high (parking choice)

- For time and cost elasticities, in many cases the different between MNL and other models are substantially high. For regret case, this might be due to the potential regret that will be faced by the person choosing that alternative.

Limitations of the study & Future recommendation

- Only two generic attributes for all models ➔ can not capture other significant factors that influence the decision especially in the multi-attribute choice context

- We do not have unlabeled data with three alternatives.

- For future study, it would be better to add more RP data so that we can better compare and draw more conclusion.

- Since the modeling approaches that we presented here are a context-dependent model, different choice sets and different context might produce different results ➔ more empirical results are necessary

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References

- Chorus, C. G. (2010) A new model of random regret minimization, *European Journal of Transport and Infrastructure Research*, **10** (2) 181-196.
- Chorus, C. G. and M. Bierlaire (2013) An empirical comparison of travel choice models that capture preferences for compromise alternative, *Transportation*, **40** (3) 549-562.
- Chorus, C. G., T. A. Arentze and H.J.P. Timmermans (2008) A Random Regret-Minimization model of travel choice, *Transportation Research Part B: Methodological*, **42** (1) 1-18.
- Chorus, C.G., J.M. Rose and D.A. Hensher (2013a) Regret minimization or utility maximization: It depends on the attribute, *Environment and Planning Part B*, **40** (1) 154-169.
- Chorus, C.G., M. J. Koetse and A. Hoen (2013b) Consumer preferences for alternative fuel vehicles: Comparing a utility maximization and a regret minimization model, *Energy Policy,* **61**, 901-908.
- Chorus, C.G., S. Van Cranenburgh and T. Dekker (2014) Random regret minimization for consumer choice modelling: Assesment of empirical evidence, *Journal of Business Research*, **67** (11) 2428-2436.
- Hensher, D.A, W.H. Greene and C.G. Chorus (2013) Random regret minimization or random utility maximization: An exploratory analysis in the context of automobile fuel choice, *Journal of Advanced Transportation,* **47** (7) 667-678.
- Leong, W. And D.A. Hensher (2015) Contrast of Relative Advantage Maximisation with Random Utility Maximisation and Regret Minimisation, *Journal of Transport Economics and Policy*, **49** (1) 167-186.
- Thiene, M., M. Boeri and C.G. Chorus (2012) Random regret minimization: Exploration of a new choice model for environmental and resource economics, Environmental and Resource Economics, 51 (3) 413-429.
- Van Cranenburgh, S., C.A. Guevara and C.G. Chorus (2015) New insights on random regret minimisation model, Transportation Research Part A: Policy and Practice, 74, 91-109.