

# Application of rrm as behavior mode choice on modelling transportation

**M S Surbakti<sup>1</sup> and A F Sadullah<sup>2</sup>**

<sup>1</sup> Civil Engineering Department, Faculty of Engineering. Universitas Sumatera Utara, Jl Perpustakaan No. 1, Medan, Indonesia

<sup>2</sup> Faculty of Civil Engineering, Engineering Campus, USM, Nibong Tebal, Penang, Malaysia

E-mail: medissurbakti@yahoo.com

**Abstract.** Transportation mode selection, the first step in transportation planning process, is probably one of the most important planning elements. The development of models that can explain the preference of passengers regarding their chosen mode of public transport option will contribute to the improvement and development of existing public transport. Logit models have been widely used to determine the mode choice models in which the alternative are different transport modes. Random Regret Minimization (RRM) theory is a theory developed from the behavior to choose (choice behavior) in a state of uncertainty. During its development, the theory was used in various disciplines, such as marketing, micro economy, psychology, management, and transportation. This article aims to show the use of RRM in various modes of selection, from the results of various studies that have been conducted both in north sumatera and western Java.

## 1. Introduction

Generally, commuters of public transportation have different preferences about how they select a vehicle. The development of models that can explain the preference of passengers regarding their chosen mode of public transport option will contribute to the improvement and development of existing public transport.

Logit models have been widely used to determine the mode choice models in which the alternative are different transport modes. Another proposed transportation model is the spike model, a parametric model that can be used to estimate the willingness to pay, and which enables specific respondents to have zero willingness to pay.

Regret theory is a theory developed from the behavior to choose (choice behavior) in a state of uncertainty. During its development, the theory was used in various disciplines, such as marketing, micro economy, psychology, management, and transportation [3].

Since the mid-seventies, the majority of disaggregate travel demand models (with logit basis model) are based on the notion of random-utility-maximization (RUM) [10][11]. These RUM models assume that a traveler selects the one that has the highest utility when faced with several travel options.

Random regret minimization (RRM) is rooted in regret theory [1][8][9]. RRM asserts that an individual's choice between alternative is based on his or her wish to avoid the situation whereby a discarded alternative turns out to be more attractive than the one chosen, which would cause regret.



Hence, the individual is assumed to minimize anticipated regret when choosing between alternatives, as opposed to maximizing utility.

This article aims to show the use of RRM in various modes of selection, from the results of various studies that have been conducted both in north sumatera and western Java, and compare the result with other mode choice model, such as RUM.

## 2. Random utility maximization (RUM) and random regret minimization (RRM)

The RUM postulates that 1. Individuals belong to a given homogeneous population  $Q$ , act rationally, and possess perfect information, that is, they always select the option that maximizes their net personal utility (this species has been identified as 'Homo economicus') subject to legal, social, physical, and/or budgetary (both in time and money terms) constraints. 2. A certain set  $A = \{A_1, \dots, A_j, \dots, A_N\}$  of available alternatives and a set  $X$  of vectors of measured attributes of the individuals and their alternatives exist. A given individual  $q$  is endowed with a set of attributes  $x \in X$  and in general will face a choice set  $A(q) \in A$ . 3. Each Option  $A_j \in A$  has an associated net utility  $U_{jq}$  for individual  $q$ . The modeler, who is an observer of the system, does not possess complete information on all elements considered by the individual making a choice.

From above postulates, can construct an equation that is:

$$U_{jq} = V_{jq} + \epsilon_{jq} \quad (1)$$

Which allows two apparent 'irrationalities' to be explained: that two individuals with the same attributes and facing the same choice set may select different options, and some individuals may not always select the best alternative (from the point of view of the attributes considered by the modeler).

To be correct, Equation 1 requires a certain homogeneity in the population under study, and to achieve this homogeneity requires segmentation of the market.  $V$  representative carries the subscript  $q$  because it is a function of the attributes  $x$  and may vary from individual to individual. Residuals  $\epsilon$  are can be assumed to be random variables with mean 0 and a certain probability distribution that will be specified.

$$V_{jq} = \sum_k \theta_{kj} X_{jkq} \quad (2)$$

Where the parameters  $\theta$  are assumed to be constant for all individuals (fixed coefficient model) but vary across alternatives.

The individual's  $q$  select the maximum-utility alternative, that is, the individual chooses  $A_j$  if and only if:

$$U_{jq} \geq U_{iq}, \forall A_i \in A(q) \quad (3)$$

that is

$$V_{jq} - V_{iq} \geq \epsilon_{iq} - \epsilon_{jq} \quad (4)$$

as the analyst ignores the value of  $(\epsilon_{iq} - \epsilon_{jq})$ , thus the probability of choosing  $A_j$  is given by:

$$P_{jq} = Prob \{ \epsilon_{iq} \leq \epsilon_{jq} + (V_{jq} - V_{iq}), \forall A_i \in A(q) \} \quad (5)$$

Regret theory states that alternative  $i$  was selected from a choice set containing  $i$  and  $j$  if and only if;

$$\sum_{s \in S} [p(s) \cdot R_{ij}(s)] > 0 \quad (6)$$

Where :

s = as a representation of the events / circumstances that occur

S = all the possibilities that exist

p(s) = s probability of events occurring

$R_{ij}(s)$  = regret value (a negative value, if the current state j, is more interesting than i) of alternative i compared to alternative j, while the incidence of "s" occurs.

Regret initially developed to assess risk selection in a lottery to choose a choice between two options, but its development in the analysis of travel needs (travel demand) gives good results.

Early development of the theory of regret by the Chorus (2008) produces a formula that is more extensive and can be used in a multinomial selection [2].

If a rider n, which faces a choice between alternative i, j and k where each alternative has attributes x, y and z a dummy variable, thus:

$$i = \{x_i, y_i, z_i\}; \quad j = \{x_j, y_j, z_j\}; \quad k = \{x_k, y_k, z_k\};$$

based on regret theory then, the value of the regret that would be linked by a rider is equal to the regret associated with the value to compare all regret, of all the existing alternatives:

$$\begin{aligned} R_i &= \max \{R_{ij}, R_{ik}\} \\ R_j &= \max \{R_{ji}, R_{jk}\} \\ R_k &= \max \{R_{ki}, R_{kj}\} \end{aligned} \quad (7)$$

Where to regret binaries contained in the above equation, the amount of regret that obtained for each alternative is obtained from the maximum possible regret the outcome of one-on-one comparisons between the attributes of the alternative with other alternatives.

For example, to compare the binary regret of alternative i j,  $R_{ij}$  is :

$$R_{ij} = \varphi_x(x_i, x_j) + \varphi_y(y_i, y_j) + \varphi_z(z_i, z_j) \quad (8)$$

Where :

$$\varphi_x(x_i, x_j) = \max\{0, \beta_x \cdot (x_j - x_i)\}$$

$$\varphi_y(y_i, y_j) = \max\{0, \beta_y \cdot (y_j - y_i)\}$$

$$\varphi_z(z_i, z_j) = \max\{0, \beta_z \cdot (z_j - z_i)\}$$

$\beta_x$ ,  $\beta_y$  and  $\beta_z$  Parameters are coefficient that obtained from the selected alternative.

### 3. New random regret minimization

In 2010, Chorus has made changes to the model to reduce the limitations of its formula, and it has change as shown at this formula bellow [3].

$$\bar{R}_i = \sum_{j \neq i} \sum_{m=1..M} \ln(1 + \exp[\beta_m \cdot (x_{jm} - x_{im})]) \quad (9)$$

For the probability, the choice of a common form used is the result of the adoption multinomial logit formula, by maximizing the negative random regret, which can be written as follows:

$$P_i = \frac{\exp(-\bar{R}_i)}{\sum_{j=1..J} \exp(-\bar{R}_j)} \quad (10)$$

#### 4. Modeling mode choice behavioural with RRM and RUM

There are several studies that have been conducted in Indonesia regarding the use of RRM methods compared with the RUM method.

##### 4.1. Application of RRM for modelling Jakarta-Bandung mode choice behavioural

This research was conducted to observe the movement of people (passengers) between Bandung to Jakarta, by taking samples of the passenger Train and Bus Travel. Survey was carried out directly on the Pool of travel bus in Bandung and on the train (on board survey).

The current competition is between modes of rail with other modes of small bus / travel bus. Prior to 2006, when the train travels time is approximately 3 hours, public buses have 4-5 hours travel time. At that time the Parahiangan train is the favorite choice for many people who travel from Bandung to Jakarta vice versa.

But along with the completion of the Cipularang Toll Road which connects Jakarta and Bandung, travel time by using a small bus down to 2-2.5 hours. And make a significant impact of increasing volume of travel bus form Bandung to Jakarta (from 3 companies at 2004 with 5-10 bus to more than 25 companies at 2011 with about 1500 bus).

At the present due to the large volume of vehicles passing the segment Bandung-Jakarta, then travel time starts to increase. On the other hand, Train Operator has done much to reduce their travel time.

Data regarding the frequency and volume of passengers every day that moves from Bandung to Jakarta are as follows:

##### 4.1.1. Train

Train schedule from Bandung to Jakarta are 8 times a day with business and executive class. The operational of train starts from 05:30 until 20:30. The train travel as far as 173 km and filled with 328 seats, with 4 executive compartment and 2 business class compartment. Business-class fare is Rp. 55,000, - while the executive fare is Rp. 80.000.

##### 4.1.2. Travel Bus mode

Preliminary research shows there are six main bus companies that serve the movement of Bandung Jakarta; Daytrans, Xtrans, Citytrans, Cipaganti, Beraya Travel and Transline. The frequency of departure varies between ½ to an hour. Each company has a poll (own vehicle terminal) separately, the hour of departure and the departure frequency varies for each pool. Bus fare varies between Rp. 60.000, - to Rp. 75.000, -

The advantage of using a small bus mode/travel mode are regard to the frequency of departure that more often than by train, also the location of the vehicle poll that spreads well in the city of origin (Bandung), as well as at destination (Jakarta). The disadvantage is more expensive than the fare of the train, as well as travel time reliability (especially when arrive or depart from Jakarta and Bandung); this is caused by the increasing volume of traffic using the Cipularang highway segment.

For resume of data attributes for both modes are as follows:

**Table 1.** Performance attribute data for each mode

Attribute	Train	Travel Bus
Fare	Rp 55.000	Rp 60.000- 70.000
Travel Time	3.5 Hour	2.5 Hour
Freq	8 times/day	Every ½ hour
operator	Argo Parahiangan	X trans, Cipaganti, CityTrans etc.

N Logit 5 an econometric software are used to analyze stated and revealed preference data for logit (RUM) model, and matlab are the tools for RRM analysis.

Some of the results obtained from the N Logit 5 analysis are shown in Table 2 below.

**Table 2.** Result for Binomial logit analysis for Stated Preference data from N Logit 5.

Binary Logit Model for Binary Choice						
Dependent variable			K			
Log likelihood function			-4776.44983			
Restricted log likelihood			-4855.16445			
Chi squared [ 6 d.f.]			157.42925			
Significance level			.00000			
McFadden Pseudo R-squared			.0162126			
Estimation based on N = 8010, K = 7						
Inf.Cr.AIC = 9566.9 AIC/N = 1.194						
FinSmplAIC = 9566.9 FIC/N = 1.194						
Bayes IC = 9615.8 BIC/N = 1.200						
HannanQuinn = 9583.6 HIC/N = 1.196						
Model estimated: Sep 27, 2013, 13:17:14						
Hosmer-Lemeshow chi-squared = 46.44489						
P-value= .00000 with deg.fr. = 8						
-----						
		Standard		Prob.	95% Confidence	
K	Coefficient	Error	z	z >Z*	Interval	
-----						
Constant	-3.21860***	.48485	-6.64	.0000	-4.16888	-2.26831
TCT	.02522***	.00305	8.27	.0000	.01925	.03120
TTT	.36835***	.06083	6.06	.0000	.24912	.48757
TCB	-.00996***	.00243	-4.09	.0000	-.01473	-.00519
TTB	-.04137	.06057	-.68	.4946	-.16008	.07734
TCA	.13490***	.02437	5.54	.0000	.08715	.18266
TTA	-.02735	.24264	-.11	.9102	-.50292	.44821
-----						
Note: ***, **, * ==> Significance at 1%, 5%, 10% level.						
-----						

From Table 2, variable TCT (Travel Cost for Train), TTT (Travel Time for Train), TCB (Travel Cost for Bus) and TCA (Total Cost for Access) are variable that significantly affect the model.

After run the same data, and analyzed with matlab for RRM method the results of the analysis by comparing binomial logit and regret minimization can be seen in the Table 3.

**Table 3.** Resume Comparison of RRM and RUM (for business and work purpose)

<i>Variable/ Parameter</i>	<i>Logit Binomia</i>	<i>SE</i>	<i>Rand. Regret</i>	<i>SE</i>
TCT	.02522	.00305	.03714	.00283
TTT	.36835	.06083	.33966	.03069
TCB	-.00996	.00243	-.00315	-.00271
TTB	-.04137	.06057	-.03710	.04246
TCA	.13490	.02437	.18623	.00129
TTA	-.02735	.24264	-.03386	.14940
Const.	-3.21860	.48485	-4.28709	.56398
Hosmer Lemeshof chi- squared	46.44489		47.59184	
AIC/N	1.194		1.114	

BIC/N	1.200	1.192
Log likelihood	-4776.4	-4776.4
Number of cases	8010	8010

#### 4.2. Studies of passenger mode choice behavioural on Medan-Balige Bus Route.

This research was conducted to observe the movement of people (passengers) between the City of Medan to Balige, by taking samples of the bus Karya Agung and Koperasi Bintang Tapanuli in Medan route - Balige. survey carried out directly on the bus counters in Medan.

Track road on this route are: Amplas Station Medan - Tanjung Morawa - Lubuk Pakam - Perbaungan - Sei Rampah – Tebing Tinggi - Siantar - Prapat - Porsea - Balige. Distance path in the network of the road from Medan - Balige is as far as 245 km.

Existing data attributes both modes are as follows:

**Table 4.** Performance Attribute data for each mode

No	Attribute	Mode Choice	
		Karya Agung	Koperasi Bintang Tapanuli
1	Travel Cost	Rp. 35.000	Rp. 40.000
2	Average Travel Time	6.5 Hour	5.5 Hour
3	Headway	every 15 minute	Every 15 minute

From the table above shows that there is a difference between the values of the attribute is the type of travel cost and travel time average. There is no difference in the frequency of departures.

In addition to the above differences, other characteristics related to transportation is the bus Karya Agung reserved seats for 17 people, while Koperasi Bintang Tapanuli reserved seat for 12 people. The operation of fleet of karya Agung carried out starting at 8 am until 20:00 pm, while the bus Koperasi Bintang Tapanuli operate for 24 hours, but for certain hours (early morning) the frequency of vehicle departure to 30 minutes - 1 hour.

The results of the analysis using software biogeme 1.8, to the selection of the two bus modes, by comparing the results of the analysis using the binomial logit and regret minimization can be seen in the table below.

**Table 5.** Resume Comparison of RRM and RUM

		Random Regrete	Logit Binomial	
From the above it can be	<b>Const</b>	-1.642	-1.2452	table
	<b>Cost</b>	-0.265	-0.427	
	<b>Time</b>	-0.032	-0.023	
	<b>Headway</b>	-0.003	-0.002	
	<b>Log Likelihood</b>	-82	-82	
	<b>rho square</b>	0.442	0.401	
	<b>Number of cases</b>	75	75	

concluded that there is no significant difference between the RRM and RUM both constant values in the second equation, and the coefficients of each attribute.

With the value of rho square is relatively small (less than 0.5), it can also be concluded that there are other parameters that have not entered into this discussion, so that the model cannot be formed properly explain the correlation selection mode with the observed attribute.

A negative coefficient indicates the opposite relationship exists between selections modes with the value attribute. The greater the value of an attribute, then the person would not choose alternative modes.

## 5. Resume

Both studies shows that :

1. The mode Choice in Indonesia can also be made using the RRM model, in addition to the RUM model commonly used throughout the world.
2. Binomial mode choice for vehicles with long distances, such as intercity, using RRM; As in the two studies above shows that there is consistently no significant difference between the two comparable models (RUM and RRM).
3. Differences regarding statistical modeling results, as shown by log likelihood values, Hosmer Limenshof chi square, AIC / N; this are line with similar research that has been done by Caspar in 2013.
4. Need to do further research to see the use of RRM on multimodal selection, whether It'll have the same relative results or different from RUM model.
5. In the case of further research, it is necessary to examine the impact of particular attributes of the passenger on the use of RRM such as research on passenger commuters' users, who have relatively shorter travels (less than 2 hours). Another attribute that needs to be examined for its impact on the mode selection is the presence of penalties for travel delays. This is certainly interesting since RRM is based on the psychological aspect, which is different from RUM, which is based on economic considerations

## References

- [1] Bell D E 1982 Regret in decision making under uncertainty *Operations Research* **30** (5) pp 961-981
- [2] Chorus C G, Arentze T A and Timmermans H J P 2008 A Random Regret Minimization Model of Travel Choice *Transportation Research Part B* **42** pp 1-18
- [3] Chorus Caspar G 2010 A New Model of Random Regret Minimization (Delft University of Technology)
- [4] Chorus Caspar G 2012 Random Regret Minimization: An Overview of Model Properties and Empirical Evidence *Transport Reviews* **32** (1) pp 75-92
- [5] Chorus Caspar G 2012 Random Regret-Based Discrete Choice Modeling: A Tutorial (Delft University of Technology)
- [6] Chorus C G and Dellaert Benedict G C 2010 Travel Choice Inertia: The Joint of Risk Aversion and Learning (Department of Technology, Policy, and Management Delft University of Technology)
- [7] Chorus Caspar G 2013 Random Regret Minimization: Overview of Empirical Performance and Policy Implications *International Choice Modelling Conference 2013*
- [8] Fishburn P C 1982 Non-transitive measurable utility *Journal of Mathematical Psychology* **26** (1) pp 31-67
- [9] Loomes Graham and Sudgen Robert 1982 Regret Theory: An Alternative Theory of Rational Choice Under Uncertainty *The Economic Journal* **92** (368) pp 805-824
- [10] Manski C F 1977 The structure of random utility models. *Theory and Decision* **8** pp 229-254
- [11] Marschak 1960 Binary choice constraints and random utility indicators *Arrow, K. (Ed.), Stanford Symposium on Mathematical Models in the Social Sciences* (California: Stanford University Press)
- [12] Surbakti Medis S 2017 Aplication of Random Regrete Minimization Model with Concavity and Convexity Paramter for Binomial Model Choice Analysis.USM.

- [13] Surbakti M S and Panjaitan I 2012 Comparative Analysis of Random Utility Maximisation (RUM) and Random Regrete Minimization (RRM) in Medan-Balige Travel Mode Choice Behaviour. *The 15<sup>th</sup> FSTPT International Symposium* (Indonesia: STTD Bekasi)