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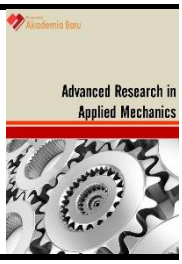

Fuzzy Set Conjoint Approach Modelling in Active Transport

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ABSTRACT

Active transport is a friendly environmental transportation that can guarantee life in an environment with high quality, clean and healthy. Green or sustainable transport is said to be as a solution for urban transportation problems because does not has any direct polluting gas emissions and fuel consumption, does not cause congestion and does not impact to the population of the city. This study was conducted to examine the extent of modelling in virtue of the respondent's situation to formulate based on the use of active transportation. An approach of a fuzzy conjoint model was chosen to describe the situation of the use of active transportation based on questionnaires with 36 items questions are categorized into three main aspects and numerical calculation which is a research question survey on the 378 respondents at UKM. This study is also conducted to identify respondents in relation to the desire factor affecting priority selection based on the factors that influence and obstruction to active transport. Results found that the most important factor that encourages students of UKM to walk or cycle has been identified which is when college is nearer to faculty, can avoid traffic jams and can reach the destinations quicker in some situations with the degree of their respective weights, 0.811 0.793 and 0.687. While the most important factor that prevents students of UKM to choose active transportation mode is weather in Malaysia that always hot and rainy, personal safety is not guaranteed from threats or wild animals and no lighting on the cycling and pedestrians at night each having degrees weights 0.814, 0.772 and 0.763.

Keywords:
Fuzzy set conjoint model, active transport, Likert scale

1. Introduction

Active transport or known as a non-motorized vehicle is activated using manpower such as walking, cycling and wheelchair [7]. Green or sustainable transport is said to be as a solution for urban transportation problems because does not has any direct polluting gas emissions and fuel consumption, does not cause congestion and does not impact to the population of the city. Tiwari *et al.*, [12] proved that the rate of carbon dioxide emissions by car is 17 percent and bus is 25 percent

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that contributes to air pollution. Thus, the greenhouse effect has become the hottest issue discussed right now where motor vehicles recorded as 26 percent production of carbon dioxide (CO2) and the transport sector is still increasing [7]. With the increase in the rate of carbon dioxide emissions by passive transport, cycling and walking are considered to be low-carbon transport mode. In this regard, cycling and walking can contribute to direct involvement towards achieving the objectives of sustainable transport, leading to a healthy lifestyle and the reduction of traffic [2].

In Malaysia, usage of private vehicles is seen as the most preferred mode of transportation. This is because private transports are more comfortable [10] and inefficient of public transport as an alternative transportation that is not effective and not able to accommodate the needs of passengers during peak hour [14]. As we can see the total number of vehicles registered with Jabatan Pengangkutan Jalan (JPJ) is 26,301,925 at the end of the year 2015 for the rest of the state in Malaysia. This shows an increase of 23 percent compared to the year 2010. Thus, the usage of passive transport is no longer relevant to accommodate the level of traffic congestion caused by an increasing number of population [2]. The total number of private vehicle accidents also increased from 511,861 to 625,758 [9]. Mode of active transport not only protect the public from exposure to the air pollution and noise but also the risk of road safety also can be reduced [11].

However, the transitions towards a more sustainable society require a better understanding when an individual making decisions that affect the choice of transportation mode [4]. Na'asah *et al.*, [8] have found that residents of Shah Alam are still far from targets to achieve the use of sustainable transport modes. This is so because of a few factors that cause the respondent did not really choose for cycling and walking. In fact, Malaysia is now often associated with bad images such as congestion, accidents and inefficient of public transport as an alternative transport. However, what is the factors that influence and obstruction in choosing active transport as an alternative mode of transport for each individual?.

2. Methods

A survey has been conducted on 378 respondents at UKM to obtain feedback on factors that influence and obstruction in choosing active transport as an alternative mode of transport. Questions posed are simple and easy to understand. In this study, priority is used as a linguistic variable and using a Likert scale of five points. Table 1 shows 5-point of Likert scale to be chosen by respondents when answering the questionnaire. A respondent may have some uncertain choices when he or she chooses a response. For an instant, the choices should be partially agreed, probably or don't know. In addition, the statement might be vague and imprecise. In order to overcome the problem, this is where the fuzzy set theory can be applied [15].

Table 1
Likert scale point

Available options	Likert scale
Strongly not priority	1
Not priority	2
Undecided	3
Priority	4
Strongly priority	5

A fuzzy set theory was introduced by Zadeh [17] to assess the level of consent and someone's interest. A fuzzy set approach has been developed to solve problems in which the descriptions of

activities are imprecise, vague and uncertainty [15]. The fuzzy set theory has an ability to describe sets of concepts in human language which the one is impossible using traditional set theory [1]. Muhamad Razuhanafi *et al*., [6] says the fuzzy set theory is an extension of classical set theory, and probability theory. If the classical set theory takes into account only the values 0 and 1 only, namely {0.1}, while fuzzy set theory in turn takes into account the value between 0 and 1 that is [0, 1], [5, 8]. The fuzzy set theory also highlighted the use of ' degree of membership ' that takes into account the value between 0 and 1. The increasingly growing value from 0 to 1 means that the higher the degree of its membership [17]. Fuzzy set theory can represent the uncertainty or vagueness inherent in the definition of linguistic variables [17]. Linguistic variables can be represented by words such as "strongly not priority", "not priority", "undecided", "priority", "strongly priority" rather. An example of fuzzy sets for visibility shown in Figure 1.

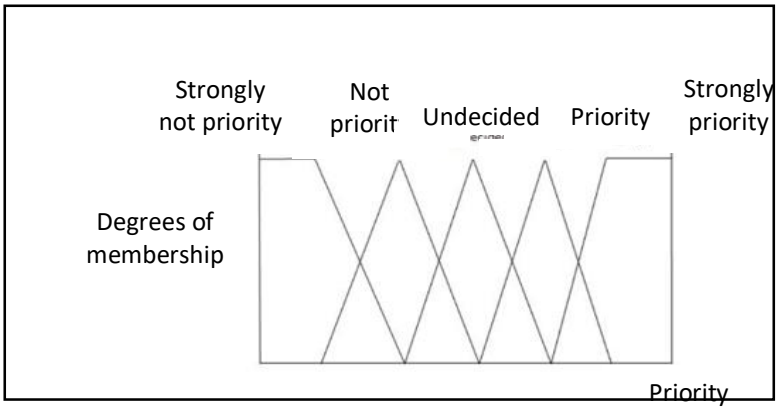

Fig. 1. Fuzzy sets for visibility

This research will use fuzzy set conjoint model adapted from Turksen *et al*., [13] to analyze the evaluation. Many studies have been employed this model which involves the use of a Likert scale to represent linguistic terms. Turksen *et al*., [13] applied this model in their study which aims to investigate customers' preferences and satisfaction on products and services. Yusoff *et al*., [16] had studied on this application of fuzzy set in an evaluation of employers' satisfaction level for the graduates' performance. One of the studies was done by Abiyev *et al*., [1] in the evaluation of job satisfaction of hotel employees, showed that the model has worked well and produces a good result in estimating overall preferences.

A theoretical ground for works using fuzzy set conjoint model has laid by Turksen *et al*., [13]. A fuzzy set R is representing the hierarchy of all respondent against the specific attributes by using this model. The degree of membership for each element, y_j (y=1,2,3,….l) in fuzzy set R is defined as

$$\mu_R(y_j, M) = \sum_{i=1}^{n} W_i \mu_{Ri}(x_j, M) \qquad (1)$$

Where $\mu_R(x_j, M)$: Degree of membership of domain element x_j in linguistic evaluation R by i[th] respondent against attribute *M* for each element in the fuzzy set R_j, x_j=*1,2,3…l*

Ri ∈ : { strongly not priority (L1), not priority (L2), undecided (L3), priority (L4), strongly priority (L5) by *i*-th respondent, *i* = 1, 2, 3….n.

W_i : Weight for *i*-th respondent and for $W_i = \frac{w_i}{\sum_{k=1}^{n} w_k}$ as w_i is a score of linguistic values given by *i*-th respondent.

L : Number of linguistic values used (in this research, l = 5).

$\mu_R(y_j, M)$: Approximate overall degree of membership of the linguistic value R for all factor M attributes.
M : Factor attributes.
n : Number of respondents.

This study according to the definition used by Turksen *et al*., [13] in defining a set of fuzzy for all linguistic value. However, Yahaya *et al*., [15] has been to modify the definition of the initial set of fuzzy linguistic value for variable priority. There are five linguistic variables with 5-point Likert scale. Table 2 defined membership functions for linguistic variables for this research.
The analysis process begins with:

1) Obtained the level of priority for all respondents based on five linguistic values.
2) Defined the five scales measured for satisfaction into a fuzzy set.
3) Obtained the weights by dividing the measurement of the respondent with a sum of measurement of all respondent.
4) Obtained membership degree of every respondent by multiplying the weight and every fuzzy set membership value accordingly.
5) Obtained the overall membership degree by total up the membership degree of every linguistic respect to linguistic value.

(Adapted from Biswas, [3])

Table 2
Membership of Likert scale

yLinguistic variable	**Linguistic value**
Strongly not priority	{1/1, 0.75/2, 0.5/3, 0/4, 0/5}
Not priority	{0.5/1, ½. 0.75/3, 0.25/4, 0/5}
Undecided	{0/1, 0.5/2, 1/3, 0.5/4, 0/5}
Priority	{0/1, 0.25/2, 0.75/3, 1/4, 0.5/5}
Strongly priority	{0/1, 0/2, 0.5/3, 0.75/4, 1/5}

3. Results and Discussion

Here are the procedures and result analysis of fuzzy set conjoint that been used:
Step 1: Determination of items that affect the primacy of the selection of respondents for choosing active or passive transportation based on the analysis of the driving factors and barriers to the mod selection of active transportation.
Step 2: For five linguistic variables, the definition of scale measurement evaluation of the subject generated by referring reference from Turksen *et al*., [13] and modification of the definition of fuzzy featured by Yahaya *et al*., [15] which only use five linguistic value.
Step 3: The level of assessment of the 378 respondents on matters to be reviewed is derived from the responses of the respondents themselves. Set of respondents marked as R= 〖(R)〗 _1,R_2,R_3,…,R_378). While the priority level set of question 1 to 32 for the 378 respondents is 1=(2,4,4,…,3) as shown in table 3.

Table 3
Respondents' opinion on recommendations of priority

	R_1	R_2	R_n	R_{378}	$\sum_{i=1}^{S} R_i$
1	4	2	.	3	717
2	4	2	.	2	674
n	.	.	.	.	.
32	3	5	.	4	1281

Step 4: Table 4 shows the calculation of weights for the level assessment of each of the respondents by dividing overall assessment of each respondent with the total assessment of all respondents.
Step 5: Weight multiplied by the definition of fuzzy set values of the linguistic equivalent of the evaluation respondents to derive the calculation of fuzzy set membership degrees of linguistic value of each respondent. RI as in Table 5.
Step 6: Total degrees of membership of each domain separately value set is the calculation of the overall set of fuzzy linguistic value, namely Li respondents as shown table 6. Results should be clear and concise. Results should be clear and concise Results should be clear and concise. Results should be clear and concise. Discussion must explore the significance of the results of the work. Adequate discussion or comparison of the current results to the previous similar published articles is recommended to shows the positioning of the present research (if available).

Table 4
Weights scale

	W_1	W_2	W_n	W_{378}
1	4/717	2/717	.	3/717
2	4/674	2/674	.	2/674
n	.	.	.	.
32	3/1281	5/1281	.	4/1281

$$\mathrm{R}_1 = \left(\frac{4}{717}\right)(\mathrm{L}_4) = \left\{\frac{0}{1}, \frac{0.25}{2}, \frac{0.75}{3}, \frac{1}{4}, \frac{0.5}{5}\right\}$$

$$\mathrm{R}_{378} = \left(\frac{3}{717}\right)(\mathrm{L}_3) = \left\{\frac{0}{1}, \frac{0.5}{2}, \frac{1}{3}, \frac{0.5}{4}, \frac{0}{5}\right\}$$

Table 5
Membership degree of overall respondents to linguistic value

	L_1	L_2	L_3	L_4	L_5
R_1	0	0.001395	0.004184	0.005579	0.002789
R_2	0.001395	0.002789	0.002092	0.000697	0
.	.	.	.	.	.
R_{378}	0	0.002092	0.004184	0.002092	0

Table 6
Overall respondents' summation of membership degree

	L_1	L_2	L_3	L_4	L_5
1	0.463040	**0.775802**	0.709205	0.346234	0.119944
2	0.489614	**0.770030**	0.711424	0.326039	0.087537
3	0.034549	0.122361	0.586372	0.778791	**0.792706**
4	0.088806	0.217164	0.611940	0.664366	**0.687313**
5	0.021332	0.177763	0.649644	**0.822075**	0.679379
6	0.024500	0.160058	0.631528	**0.810928**	0.712444
7	**0.624074**	0.600000	0.586111	0.280556	0.203704
8	0.027624	0.367798	**0.833465**	0.711721	0.305446
9	0.020757	0.10989	0.584249	0.778388	**0.810745**
10	**0.630112**	0.618030	0.591078	0.268123	0.187732
11	**0.633333**	0.601389	0.564815	0.244444	0.174074
12	**0.659615**	0.631731	0.586538	0.243750	0.167308
13	0.069479	0.399504	**0.802730**	0.632134	0.325062
14	0.062916	0.298853	0.708364	**0.752961**	0.520355
15	0.031633	0.170433	0.626856	**0.804229**	0.714655
16	0.021328	0.110603	0.582267	0.764168	**0.814138**
17	**0.617811**	0.588126	0.588590	0.284787	0.205009
18	**0.694611**	0.653194	0.582834	0.217565	0.139721
19	0.021303	0.138315	0.607769	0.735589	**0.763158**
20	0.016698	0.128015	0.605751	0.762523	**0.771800**
21	0.032755	0.111272	0.582852	0.76975	**0.801541**
22	0.009346	0.087033	0.573890	0.788405	**0.842874**
23	0.459610	**0.787604**	0.721448	0.336351	0.097493
24	0.013750	0.154375	0.635625	**0.833125**	0.715000
25	0.013483	0.311049	**0.794757**	0.671161	0.397004
26	0.028649	0.221351	0.682469	**0.772340**	0.606412
27	0.035461	0.116215	0.58285	0.766119	**0.798839**
28	0.011070	0.138684	0.623924	**0.827337**	0.741082
29	0.467133	**0.777972**	0.706294	0.334266	0.120280
30	0.019135	0.252658	**0.728207**	0.706591	0.524451
31	0.027215	0.108386	0.585127	0.776266	**0.802532**
32	0.061671	0.324941	**0.743560**	0.662763	0.451210

The data analysed will be discussed to obtain a comparison of factors that induce and prevent respondents to select the active transportation mode to move within the campus. In addition, measures to make the campus environment that can promote the use of cycling and walking can be proposed from a selection of answers by the respondent.

3.1 Factors that Encourage the Selection of Active Transportation Mode

The order of precedence which became the basis of the selection factor that encourages the selection of active transportation mode shown as in Table 7. From the data obtained, among the most priority factors that encourage respondents to walk or cycle are when the college is nearer to the faculty, can avoid traffic jams and can reach destinations quicker when walking or cycling in specific situations. These three items of three, four and eight are at a linguistic value of 'strongly priority' with the degree of weight of 0.793, 0.687 and 0.811 respectively. The analysis found that criteria 5 and 6 which can save money expenses and cost of oil prices increase are at the linguistic value of 'priority' with degree weights 0.822 and 0.811. While the factor of parking is limited in the area of faculty or college belong to the category of 'undecided' with weight degree of 0.833. Most respondents agreed item 1 and 2 which are walking and cycling can increase the level of health and

reduce the level of air pollution as factors that are not the priority for them to choose walking and cycling as alternative transport. Public parking charged and do have licensed were categorized in the level of priority of 'strongly not priority' with the degree of weights of 0.624 and 0.630.

Table 7
The position of priority level selected by respondents

No	Item	Level of priority	Weights
Factors that encourage the selection of active transportation mode			
1	Walking and cycling can increase the level of my health.	Not priority	0.775802
2	Walking and cycling can reduce the level of air pollution.	Not priority	0.770030
3	Can avoid traffic jams.	Strongly priority	0.7927060
4	Can reach destinations quicker when walking or cycling in specific situations.	Strongly priority	0.687313
5	Can save money expenses.	Priority	0.822075
6	Cost of oil prices increase.	Priority	0.810928
7	Public parking charged.	Strongly not priority	0.624074
8	Parking is limited in the area of faculty or college.	Undecided	0.833465
9	When college and faculty are nearer.	Strongly priority	0.810745
10	Do not have licensed	Strongly not priority	0.630112
Factors that inhibit the selection of active transportation mode			
11	The weakness of the public transport system (bus campus)	Strongly not priority	0.633333
12	The condition of the surface terrain filled and wide range of activities makes it difficult for walking and cycling.	Strongly not priority	0.659615
13	Walking or cycling will take too long to reach the destination.	Undecided	0.802730
14	Biking and walking route is only available in certain areas.	Priority	0.752961
15	Pedestrian and cycling not covered cause users exposed to hot weather and rain.	Priority	0.804229
16	Weather (hot weather and rain) reduce interest to walk and cycling.	Strongly priority	0.814138
17	Bicycle parking is not covered.	Strongly not priority	0.617811
18	Motor vehicle better suited to other places that the travel distance are far.	Strongly not priority	0.694611
19	There is no lighting on the cycling and walking routes at night.	Strongly priority	0.763158
20	Ensure the safety of the threat (e.g. snatch theft or wild animals)	Strongly priority	0.771800
Steps to make campus environment that can promote the selection of active transportation mode			
21	Better lighting in the campus and near the main road.	Strongly priority	0.801541
22	Provides sheltered routes or left and right of routes are planted with trees as shade.	Strongly priority	0.842874
23	Separation of pedestrian and cycling route from motor vehicle traffic by having blocks or planting trees.	Not priority	0.787604
24	Providing many routes for cycling and walking.	Priority	0.833125
25	Provide covered and locked bicycle parking.	Undecided	0.794757
26	A more interesting destination within the campus.	Priority	0.772340
27	Vibrant street lights, chairs, signage and crossing.	Strongly priority	0.798839
28	Give priority to users of pedestrian and cycling in the area that have traffic lights.	Priority	0.827337
29	Amenities in restrooms.	Not priority	0.777972
30	Provides free bicycle service or wind pump within the campus.	Undecided	0.728207
31	A white line on both sides of the road shall be clearly separated from motor vehicles.	Strongly priority	0.802532
32	Provides a class about safety	Undecided	0.743560

3.2 Factors that Inhibit the Selection of Active Transportation Mode

Safety and weather condition is the factor that considers by the respondent where in this paper shows that it reduce the interest for walking and cycling. The low lighting on the pedestrian walk for the walker and cyclist during night time as their safety consideration is the highest factor with a weight of 0.814, 0.763 and 0.772. Besides, the pedestrian way and cyclist path that are only located in a certain area and without roofing exposed the users to the unpredictable weather are the most important factor with the weight of 0.753 and 0.804. 0.803 are the highest for the unsure category with the factor of walking and cycling are taking much time. A weakness of the bus system, the geography condition of the hilly sloppy area, unprotected bicycle park and use of the vehicle to the far destination is the most unimportant factor with each weight of 0.633, 0.660, 0.618 and 0.695.

4. Conclusion

The researchers obtained useful information from the results of the fuzzy analysis of the importance of an attribute affecting respondents who could provide a clear picture of the extent for respondents' priorities to fulfil their aspirations to use active transport in UKM. Humans are always in a situation where they need to make decisions and sometimes they are often confused as very important or quite important and this model is able to provide the overall solutions. This is because the analysis made absolutely involving the whole of the individual and the results achieved is comprehensive results.

Based on the results of this study, it can be concluded that respondents generally prefer to factor in when the college is close to the faculty, can avoid traffic congestion and faster to the destination when walking or cycling in certain situations as a driving factor in the selection of an active transport mode. While the most important factor in preventing the selection of the active mode of transport is the unpredicted weather conditions, low lighting on the pathway and walking in the night and the safety from the threat.

The findings of this study help the parties involved in the transportation planning towards realizing the use of active transport in UKM. The most important steps that will encourage people in UKM to select active transport modes are to provide more exposure of lighting around the campus and provide a covered walkway to prevent users from being exposed to unpredicted weather. These measures will encourage users to use active transport modes not only for recreation but also as alternative transportation for short trips.

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