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Exploring the Prospects and Barriers for Campus Bike-share Systems for Universities in Dar es Salaam, Tanzania

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Abstract: **The increase in student enrollments in Tanzanian universities has resulted in most of the students living off campuses. The dependency on loans from the government makes it difficult for most of these off campus students to meet accommodation costs and transportation fares in a city that is facing the extreme traffic congestion and increase of commercial motorcycle crashes. Thus, the need for cheap yet effective alternative mode of transport arose. Bike-share system is one of the best transportation modes that could suit the situation. This study analyzed the survey questionnaire results from major six universities located in Dar es Salaam to explore the demand, opportunities and challenges for bike-share system as an alternative mode of transportation. It was revealed that the demand for bike-share system was moderate. Among 604 respondents, 35%, 41% and 36% were likely to use bike-share system for commuting, intra-campus and off-campus movement respectively if the system could be made available. Ordered model revealed that campus size, male students, time saving and reduction of walking trips motives, and students who plan to use the bike-share for going to classes were associated with reporting "likely" to use bike-share systems on the other hand fear for traffic crashes, perception that biking is tiresome transport and theft/robbery problem were the main barriers for bike-share system.**

Keywords**: Campus Bike-share systems, ordered probit model.**

I. BACKGROUND OF THE STUDY

Bike-share system (BSS) is among the recent initiative to inspire more people especially those making short trips to desert vehicles and start biking while saving money and gaining health benefits. It is very convenient mode of transport in such a way that a user can pick and drop a bike at any self-serviced station within the system. Most of cities and universities in developed countries implemented this system in order to reduce the carbon emissions, overcome the traffic congestions and reduce single vehicle occupancy trips within the campuses while cutting costs [1]. In developing countries especially in Africa, bike-share systems have been recently introduced in cities in South Africa [2] but none of the universities have implemented.

With the increased number of enrollments for most of universities in Tanzania, accommodation on campus becomes a major problem, thus, most of students live off-campuses. In addition, the loans for meals and accommodation offered by the government [3] is not sufficient to pay house rent and use public buses locally known as daladala. Moreover, the increase of traffic congestion which results into delays [4] makes "daladala" undesirable mode of transportation, thus, most people in rush including students opt for commercial motorcycle locally known as "bodaboda" which are prone to crashes [5]. Apart from being restricted in some areas especially in the central business district (CBD) due to security reasons, the commercial motorcycle drivers' charger higher fare compared to public buses. Most of students cannot afford such costly fare in regular basis. For these reasons, significant number of people including students rely on the public buses in their daily travel, however, these buses are not good candidates for short trips especially in the central business district (CBD) due to long waiting time at the bus stops [6] especially during off peak hours. All those factors call for an alternative mode of transport which is more economical and appropriate for short trips. Bike-share system can well suit the colleges and universities students, for both CBD as well as sub-urban locations for both on campus as and off campus

activities. However, the challenges, opportunities for the bike-share system are yet to be explored. The study enabled understanding bike-share system prospects and barriers for universities students in Dar es Salaam.

II. PREVIOUS STUDIES

Since its evolution in 1960's, bike-share system has passed through four main generations where by the current generation uses wireless communication and are solar powered [7]. Although the system has existed for more than 50 years, its popularity was gained in late 1990's where over 800 cities around the world registered its use [7] deploying approximately 240,000 bicycles [8]. With that huge number of bike fleet, African cities remain behind with only two cities having bike-share systems [2]. Apart from cities, universities adopted bike-share systems to reduce the single occupant trips for the university communities. In 2010, Shaheen et al [9] reported that there were more than 65 university campuses implemented different forms of bike sharing systems in the United States only. Other Asian universities have also implemented this system [7] but and none of African universities has. Regarding the utilization, bike-share users are more likely to be male with average education level [7] having culture of cycling and aged between 18 and 50 years [2] living and working in the inner city. Most of bike-share users are motivated by the cost saving. Although, traffic safety, theft and vandalism and poor weather conditions remained the main challenges for bike-share system [10 &11]. University campuses have been identified as the sources and attractors for bike-share trips [12 &13]. In attempt to establish campus bike-share systems, numerous studies have utilized questionnaire survey to quantify different parameters of the bike-share systems. There were variations in the likeliness of the campus bike-share systems among the university communities. Brougham et al [14] found that 63% of students were interested in a bike-share system after analyzing 800 responses. The highest stated demand (84%) was reported by Jennifer [15] after analyzing total of 252 responses. Work et al [16] found that most of the reported users (40%) wanted to use the bike-share for commuting with a typical use of 4 times or more every week during the semester [17]. It can be observed that most of the studies regarding university campus bike-share systems were performed in the developed countries but almost none is from African countries regardless of having traffic congestion problems, although, some efforts at the city level have been observed [2 & 18]. Therefore, by exploring various factors associated with the demand and challenges for bike-share system, this study paved a way for interested researchers in bike-share systems in Africa, specifically on the university campuses level.

III. STUDY AREA

The study was centered at Dar es Salam, Tanzania. The largest commercial city in Tanzania with total population of 4,364,541 [19] characterized by hot and humid weather condition throughout the year with the average temperature of 29°C and 1000 to 1300 mm annual rainfall for the bimodal rainfall [20 & 21]. The city contains 20 out 70 universities in country whose almost 86% of students live off-campus and commute to school by either walking or public transportation. This city is facing extreme problems of traffic congestion [6] thus, it is presumed that bike-share system might be one of the alternative modes to avoid traffic congestion.

IV. METHODOLOGY

The intensive literature review of the published and unpublished studies was performed to explore the challenges and opportunities for bike sharing system particularly at the university level in the developed as well as developing countries. Questionnaire survey involving the set of closed and open-ended questions was prepared to facilitate the attainment of the study goals. Because the bike-share system is relatively new term to most of students, one paragraph explaining the bike-share system idea was included in the survey questionnaire. The variable of interest included the demographics, motives, challenges and the likeliness level. The likeliness level was divided into three categories: likely, undecided and unlikely. The respondents for the survey were the students from six universities in the city of Dar es salaam. There were two ways of distributing the questionnaire; a paper copy and online method. In order to capture different characteristics of students' response towards bike-share system, the sampling of the target universities was based on different characteristics. More importantly, the author focused on the universities location with respect to Central Business Districts (CBD), accommodation as well as spatial distribution of the buildings within the campus. Students from each university selected in random basis at the points of interests such as cafeteria, playgrounds and classrooms were supplied with 300 paper copy of questionnaires to fill and a link to the online questionnaire. Some respondents filled and returned at the same moment while others wanted more time. For the those needed more time their contacts were collected for follow-ups. This study then employed the descriptive statistics and ordered probit regression on the survey responses to determine factors that positively or negatively affect likeliness levels of bike-share system. To explicitly explore the factors, the bike-share system use was categorized into three categories of usage: commuting, intra-campus and off-campus usage.

Selected factors were varied across all three categories and the impact of each factor for each category was observed and documented. In addition, the supplemental information were obtained from students' loans data acquired from the Higher Education Students Loans Board and students' residence information from respective University residences.

V. DATA ANALYSIS

Statistical software packages Stata version 12 and Microsoft Excel were used in data analysis. In order to unambiguously analyze the demand and challenges on the bike-share system, the likeliness levels (likely, undecided and unlikely) of the respondents were assessed in all three aspects of the BSSs uses (commuting, intra-campus movements and off campus uses)

Descriptive statistics:

Demographic nature of the respondents:

With the response rate of 33.6%, a total of 604 responses were collected by which the minimum number response by a single university was 72 from Institute of Financial Management (IFM) and the maximum number response was 154 from University of Dar es salaam UDSM. Of the 604 respondent, 590 revealed their gender of which 429 respondents (72.7%) were male while the rest (27.2%) were female. More than 90% of the respondents aged between 20 and 30 years, most of them (84%) living off-campus and greatly (77%) depend on loan from the government. It is also important to note that, commuter buses locally known as "daladala" and walking were the most common modes of transportation with 44.3% and 39. 6% share respectively. Few (3.8%) had their own bikes and even less (3.6%) were using their personal cars. The responses show that more than 55% of respondents were in their either first or second year of study.

Willingness to use the campus bike-share system:

In general, the reported likeliness level for students to be involve in the bike-share system in studied sample was moderate with about 35%, 41% and 36% of the respondents who reported "likely" to use bike-share system for commuting, intra-campus and off-campus movement respectively if the system could be made available.

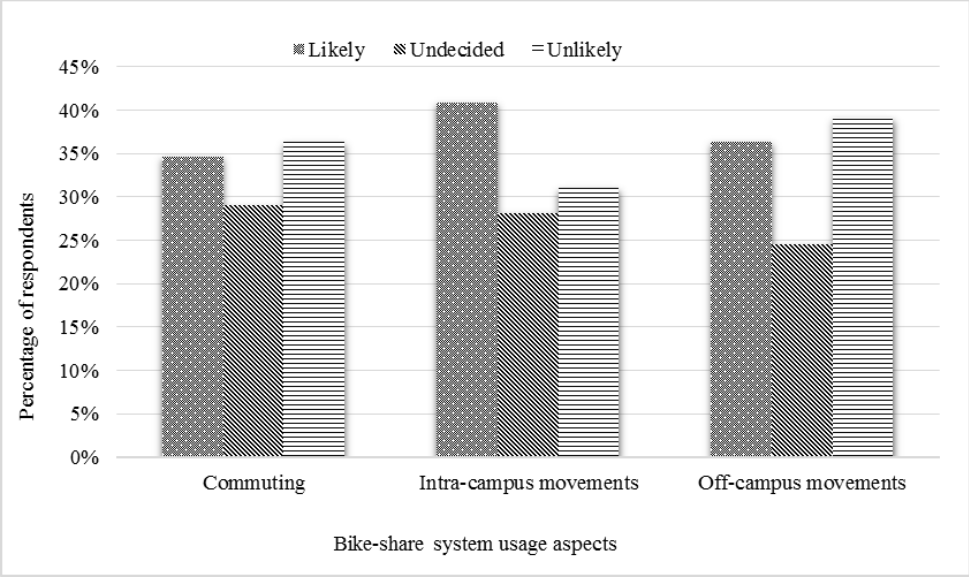

Fig. 1 General likeliness of bike-share systems

Extending the analysis, it can be observed that almost the same percentage of the respondent chose "unlikely' to use bike-share system for commuting (36%) and off-campus movements (39%). It can also be observed that there is a slight difference in respondents who were likely to use the bikes for commuting and off-campus movement. The percentage of the undecided students is roughly the same for all three aspects. This might explain the fact that bike-share systems is a new initiative, therefore, most of the people are not familiar but want to join it although they are not sure.

Campus bike-share system's stated challenges:

The fear of traffic crashes, lack of bike lanes, weather condition, security and cost were some of the challenges considered by respondents. In a general picture, the survey results revealed that about 28% of respondents perceived that traffic safety was the major challenge (Fig. 2). The second main challenge according to 26% of the respondents was the lack of

bike lanes. Mbuya et al [23] also observed safety as a significant barrier on biking in Dar es Salaam by 75% of their respondents. Theft/robbery and vandalism was not highly rated by most of the respondents, only 12% of the respondents did not feel secured riding bikes due to robbery. Through literature review, poor weather condition was considered to be one of the major challenges for bike-share systems. Hot and rainfall season were described by Ahmed, et al. [11] to be the barriers of the riding a bike in cities. With average of 29^{o}C, Dar es Salaam is one of the hot cities in Tanzania, however, the survey results confirmed that weather condition was not much critical problem compared to safety and infrastructure. Perception and ability to ride a bike also affected the willingness to use bicycle as mode of transportation. About 4% of students perceived shameful to ride a bike in city by because it is considered as a low-class mode of transport. Also, 8.67% reported that they do not know how to ride bike. Most of these findings coincide with the study by Nkurunziza et al [18] but with different percentage magnitude.

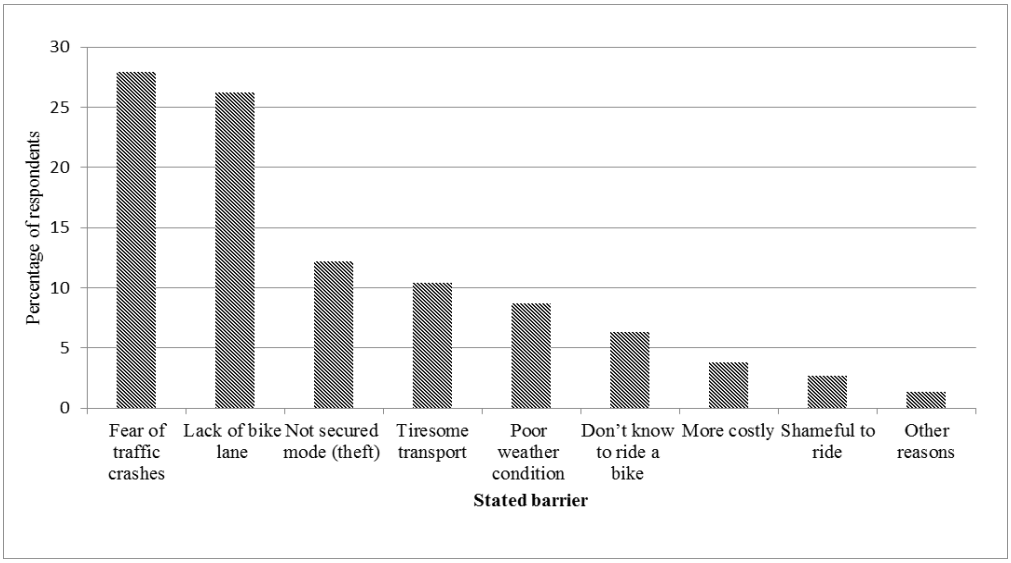

Fig. 2 Stated barriers for bike-share systems

VI. MODELING METHODOLOGY

Regardless of the accounting for the categorical nature, the unordered response models, such as the multinomial logit and probit models, or the nested logit model would fail to account for the ordinal nature [24] of the likeliness to use bike-share system. Alternatively, ordered response models, which comprise of ordered probit (OP) and logit (OL) models have been employed for modelling dependent variables with ordered responses. Both OP and OL give similar results, however, OP is most preferred due to the ability of distinguishes unequal differences between ordinal levels [25].

Based on McElvey and Zavoina [26], the ordered probit model is built around a latent regression model:

$$y^{*} = \sum \beta_i X_i + \varepsilon \qquad (1)$$

where X_i represents explanatory variables that influence the extent of likeliness of bike-share system; y^{*} is the dependent variable that is unobservable, and represents the extent of likeliness of bike-share system; β_i represents the vector of parameters to be estimated; and ε denotes the error term following standard normal distribution. Let y represent the variable of the observed likeliness. Based on the ordered probit model, y can be determined by the unobserved variable y^{*} as follows [27]:

$$y_i = \begin{cases} 1, \text{if} z_i \le \mu_1 \\ k, \text{if } \mu_{k-1} \le \mu_k \\ K \text{ if } z_i > \mu_{K-1} \end{cases} \qquad (2)$$

Where $\mu = \{\mu_1, \ldots, \mu_k, \ldots, \mu_{K-1}\}$ are the threshold values for all the levels; K is the highest level. Both thresholds μ and model parameters β are unknown parameters and are to be estimated jointly [24]. When interpreting the ordered probit model, a positive value of β_i implies that an increase in X_i will result into the increase of the probabilities of the highest levels. However, marginal effects provide the clear direction of the probability for each level. [25].

Descriptive statistics of variables

All dependent and independent variables to be used in the Ordered probit model were coded and presented in Table 1.

Table 1: Descriptive Statistics of Variables

Variable	Variable type	Obs	Mean	Std. Dev.
Dependent variables				
Commuting aspect	Categorical (0= unlikely, 1=undecided, 2=likely)	369	1.016	0.844
Intra-campus aspect	Categorical (0= unlikely, 1=undecided, 2=likely)	587	0.901	0.869
Off-campus aspect	Categorical (0= unlikely, 1=undecided, 2=likely)	583	1.027	0.844
Independent variables				
Campus Size (acre)	Continuous	607	0.257	0.437
Going to classes	Binary (1 = Yes, 0 = No)	607	0.133	0.340
Male Students	Binary (1 = Yes, 0 = No)	593	0.727	0.446
Time saving	Binary (1 = Yes, 0 = No)	607	0.376	0.485
Reduce walk trips	Binary (1 = Yes, 0 = No)	607	0.245	0.431
Fear of crashes	Binary (1 = Yes, 0 = No)	607	0.282	0.450
Unsecured mode (theft/robbery)	Binary (1 = Yes, 0 = No)	607	0.120	0.326
Tiresome transport	Binary (1 = Yes, 0 = No)	607	0.094	0.292
Commuter bus users	Binary (1 = Yes, 0 = No)	372	0.478	0.500
Motorcycle users	Binary (1 = Yes, 0 = No)	372	0.078	0.268
Bicycle users	Binary (1 = Yes, 0 = No)	372	0.032	0.177
Walk	Binary (1 = Yes, 0 = No)	372	0.368	0.483
Others	Binary (1 = Yes, 0 = No)	372	0.011	0.103

The dependent variables which were the likeliness levels of using bike-share system for all three aspects of usage were coded as 1 for “unlikely”, 2 for “undecided” and 3 for “likely”. Almost all the Independent variables shown in Table 1 were binary where by code 1 implies that a particular variable while was selected by the respondent while code 0 means otherwise. The averages and standard deviations for each variable is presented in Table 1.

Results and discussion:

Commuting aspect:

The effect of different variables were assessed for all three aspects of bikes share system. Commuting aspect was used as the base for comparison with other aspects. The magnitude of the coefficients and significant level were observed to differ for different aspects as presented in Table 2, Table 3 as well as Table 4. The marginal effects were also presented in the same respective Tables. The computation of the marginal effects were based on the probability that students would report “likely” to use the bike-share system for a particular aspect.

Table 2: Ordered Probit Results for Commuting Use of Bike-share System

Number of obs =	358	Pseudo R^2 =	0.1667		Average marginal effects			
LR $chi^2(13)$ =	119.21	Log likelihood =	-319.5		Pr (likely)			
Prob > chi^2 =	0.000				Number of obs = 358			
Commuting aspect	**Coef.**	**Std. Err.**	**z-stat**	**P-value**	**dy/dx**	**Std. Err.**	**z**	**P-value**
Campus Size	0.365	0.157	2.32	0.020	0.110	0.046	2.36	0.018
Male Students	0.581	0.154	3.76	0.000	0.175	0.045	3.90	0.000
Time saving	0.733	0.141	5.20	0.000	0.220	0.039	5.63	0.000
Reduce walk trips	0.290	0.160	1.82	0.069	0.087	0.047	1.84	0.066
Fear of crashes	-0.746	0.149	-5.02	0.000	-0.224	0.042	-5.33	0.000
Unsecured mode (theft)	-0.587	0.206	-2.85	0.004	-0.177	0.061	-2.90	0.004
Tiresome transport	-0.491	0.216	-2.27	0.023	-0.147	0.064	-2.29	0.022

Current transport mode								
Commuter bus users	0.081	0.386	0.21	0.833	0.023	0.108	0.21	0.831
Motorcycle users	-0.015	0.449	-0.03	0.973	-0.004	0.125	-0.03	0.973
Bicycle users	1.114	0.554	2.01	0.044	0.354	0.165	2.15	0.032
Walk	0.559	0.389	1.44	0.150	0.173	0.110	1.57	0.117
Others	0.548	0.667	0.82	0.411	0.169	0.209	0.81	0.418
/cut1	0.333	0.393						
/cut2	1.270	0.396						

Regarding the bike usage for commuting (Table 2), at 5% significance level, the campus size, male students, time saving motive and commuters using their own bikes were associated with reporting "likely" use of bike-share system. In addition, at 10% significance level, students who aimed at reducing walk trips were found to be more likely to report the same. Commuter bus and motorcycle users were not statistically significant at 10% level although were associated with reporting "likely" use of bike-share system.

It can be observed that the students who commute to campus by using their own bikes were 35.4% more likely to respond "likely" to use bike-share system. This observation might imply that this group of people was aware of the bikes usage and they feel comfortable utilizing them. The time sensitive students (time saving) were 22% while male students were 17.5% more probable to report "likely" to use bike-share system. Based on the size of the campus, one-acre increase of the campus size increases the chance of reporting the "likely" utilizing bike-share system by 11%.

In contrary, the fear for crashes decreases the chance of reporting "likely" to use bike-share system by 22.4% while the theft problem decreased the chance of the same by 17.7%. In addition, students who perceive bike-share system as a tiresome mode were unlikely prioritize use of bike-share system.

Intra-campus aspect

Comparing to the commuting aspect, slightly different results were observed when the intra-campus aspect of bike-share system was considered (Table 3).

Table 3: Ordered Probit Results for Intra-Campus Use of Bike-share System

Number of obs =	352	Pseudo R^2 =		0.1667	Average marginal effects			
LR $chi^2(13)$ =	127.84	Log likelihood =		-319.5	Pr (likely)			
Prob > chi^2 =	0.000				Number of obs = 352			
Intra-campus aspect	**Coef.**	**Std. Err.**	**z**	**P-value**	**dy/dx**	**Std. Err.**	**z-stat**	**P-value**
Campus Size	0.726	0.165	4.40	0.000	0.201	0.043	4.64	0.000
Male Students	0.417	0.157	2.65	0.008	0.115	0.043	2.69	0.007
Time saving	0.415	0.144	2.88	0.004	0.115	0.039	2.94	0.003
Reduce walk trips	0.396	0.163	2.44	0.015	0.110	0.044	2.48	0.013
Fear of crashes	-0.739	0.157	-4.71	0.000	-0.205	0.042	-4.92	0.000
Unsecured mode (theft)	-0.545	0.212	-2.57	0.010	-0.151	0.058	-2.59	0.010
Tiresome transport	-0.428	0.226	-1.90	0.058	-0.119	0.062	-1.91	0.056
Going to classes	0.880	0.215	4.09	0.000	0.244	0.056	4.36	0.000
Current transport mode								
Commuter bus users	0.627	0.451	1.39	0.164	0.140	0.082	1.70	0.089
Motorcycle users	0.438	0.503	0.87	0.384	0.092	0.098	0.94	0.347
Bicycle users	1.158	0.606	1.91	0.056	0.296	0.152	1.95	0.052
Walk	0.969	0.452	2.14	0.032	0.237	0.084	2.82	0.005
Others	0.839	0.752	1.12	0.264	0.199	0.193	1.03	0.302
/cut1	0.915	0.454						
/cut2	1.842	0.459						

On this aspect, comparing to the commuting aspect results, there was no change in the coefficient signs but there existed changes in significance levels of the variables. Walk as a mode of transport to campus became significant at 5% level **(**Table 3**)**. The currently bike users and those intending to reduce walking trips had the highest and the lowest magnitude

of impact respectively on reporting "likely" to use bike-share system. Being a current bike user increased the probability of reporting "likely" by 29.6% while the need to reduce walking trips increased the possibility of reporting the same by 11 percentage points. It was also observed that the use of bikes to go to classes increased the chance of reporting "likely" to use bike-share by 24.4%. One-acre increase of the campus size increased the likelihoods of reporting "likely" to use bike-share system by 20.1%. Compared to the students who commute by their personal cars, students who walk had 23.7% higher odds to report "likely" to use bike-share system (Table 3).

On the other hand, students who fear for traffic crashes, those who perceives that biking is a tiresome transport and who feel unsecured due to robbery problem were less likely to rank "likely" to use bike-share system. Ranking in descending order of the impact, the marginal effects (Table 3) show that the fear for traffic crashes decreased the chance of reporting "likely" to use bike-share system by 20.5 percentage point followed theft (15.1%) and tiresome (11.9%).

Off-campus aspect:

For the case of off-campus use of bike-share system (Table 4), compared to the commuting aspect the number of variables that were statistically significant declined substantially. Only three variables (male students, time saving motive and fear for crashes) were statistically significant at 5% level. Additionally, other two (campus size and reduction in walk trips) were statistically significant at 10% level. All the remained variables were not statistically significant at 10% level.

Table 4: Ordered Probit Results for Off-Campus Use of Bike-share System

Number of obs = 350		Pseudo R2 = 0.094				Average marginal effects			
LR chi^2(13) = 70.36		Log likelihood = -339				Pr (likely)			
Prob > chi^2 = 0.000						Number of obs = 350			
Off-campus aspect	**Coef.**	**Std. Err.**	**z-stat**	**P-value**		**dy/dx**	**Std. Err.**	**z-stat**	**P-value**
Campus Size	0.303	0.161	1.88	0.060		0.101	0.053	1.90	0.057
Male Students	0.588	0.159	3.71	0.000		0.197	0.051	3.85	0.000
Time saving	0.626	0.142	4.42	0.000		0.209	0.044	4.73	0.000
Reduce walk trips	0.300	0.158	1.89	0.058		0.100	0.052	1.92	0.055
Fear of crashes	-0.435	0.151	-2.89	0.004		-0.146	0.049	-2.96	0.003
Unsecured mode (theft)	-0.156	0.202	-0.77	0.441		-0.052	0.068	-0.77	0.440
Tiresome transport	-0.319	0.214	-1.49	0.136		-0.107	0.071	-1.50	0.134
Current transport mode									
Commuter bus users	-0.278	0.377	-0.74	0.460		-0.094	0.131	-0.72	0.472
Motorcycle users	-0.330	0.439	-0.75	0.452		-0.111	0.149	-0.74	0.457
Bicycle users	0.236	0.531	0.44	0.657		0.083	0.186	0.45	0.656
Walk	0.064	0.380	0.17	0.866		0.022	0.132	0.17	0.866
Others	0.305	0.665	0.46	0.647		0.107	0.233	0.46	0.645
/cut1	0.196	0.384							
/cut2	0.846	0.386							

Male students were 19.7% more likely to report "likely" to use bike-share system. This percentage is slightly lower than the one for students who intent to use bike-share system to save time. The larger the campus the higher is the likelihood of reporting likely to use bike-share system for off campus usage. On the other hand, the fear for crashes remained to be a major challenge for off-campus movements. Students who fear for crashes were 16.6% less likely to report "likely" to use bike-share system. Surprisingly, theft problem was not found to be statistically significant problem considering the prevalence of the problem in the city.

VII. CONCLUSION AND RECOMMENDATIONS

The objective of study was to determine the opportunities and challenges for the likeliness of bike-share system for the university campuses in Dar es salaam, Tanzania.

It was found that campus size, gender, time saving and reduction of walking trips were the most important factors that played part for all the aspects of the bike-share system. Male students were more likely to report "likely" to use bike-share

system so did the time sensitive students and those who want to reduce walk trips. The large the campus size the higher the chance for reporting the likely to use bike-share system. Significance level varies across different aspects of bike-share system. The use of bike-share system for accessing classes was only relevant for intra-campus movement only. The current mode of transport also played a significant role in likeliness of the bike-share system with biking and walking student being more likely to favor bike-share system.

Despite of the demand and opportunity of the BSSs, number of challenges were revealed. Fear for traffic crashes was found to be the most important factor that negatively affects reporting of bike-share system usage for all the three aspects. Lack of security (theft problem) was the second most negatively factor for bike-share system factor. However, this factor was not statistically significant for off-campus usage. Other factors included the feel that bike-share system is a tiresome and shameful mode of transport while not knowing to ride bikes was also mentioned.

Generally, through literature review, questionnaire survey and ordered probit models, it can be concluded that the demand for bikeshare system at the university level in Dar es Salaam is moderate. However, there is a need to address controllable issues such as bike lanes, theft and crashes which were the challenges revealed through the survey. This can be achieved by cooperating with planning and law enforcement agencies. Moreover, provision of education through different groups on the use of bike as alternative mode of transportation should be emphasized. Lastly, if bike-share system is to be introduced, the bikes model should be with impressive appearance so that to capture as much of the undecided group of students.

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