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Clusters of Bicycle Taxi Operators and their Main Service Operation Patterns: Case Study of Quelimane, Mozambique

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Abstract

Bicycle taxi is a vital means of informal public transport service in most Sub-Saharan African cities, and for this reason, understanding who operates this service, and how they operate could help define initiatives to promote this service. This study considered clusters of bicycle taxi operators and their main service operation patterns. A survey was conducted among 105 regular bicycle taxi operators in Quelimane, Mozambique. Twostep cluster analysis identified homogeneous groups of bicycle taxi operators based on six socio-economic factors (age, income, education, household composition, bicycle ownership, and residence location). A Mann-Whitney U test was employed to compare pairs of clusters of bicycle taxi operators regarding a set of taxi services operation variables, such as the number of passengers carried daily, daily revenues, and service hours. Four clusters of bicycle taxi operators were identified which are, less-educated operators from large households (C1), educated migrants (C2), less-educated bicycle renters (C3), and young cyclists from small households (C4). When comparing differences in service operation patterns per cluster of bicycle taxi operators, the study showed that people in C1 produced fewer bicycle taxi trips than those in C2 and C4. For daily earnings, people in C2 earn more than those in C1 and C3. For service hours, individuals in C2 cycle long service hours when compared to those in C1, which could be harmful to their health. The result of this study could reorient bicycle taxi service promotional policies to make the service more sustainable.

Keywords: *Bicycle taxi operators, Clusters, Daily revenues, Passengers carried, Service hours*

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Introduction

Bicycles in most of Sub-Saharan African (SSA) cities have multiple roles, for commuting, selling goods on the streets and as a source of flexible jobs such as bicycle taxi (Mendiate *et al.*, 2022; Mutiso & Behrens, 2011). These bicycle functions are a response to poverty, a rapid and physically fragmented growth of cities, which consequently raises the costs of providing road infrastructures and transport services that serves the need of growing demands (Lall *et al.*, 2017).

A bicycle taxi is a bicycle with a padded cushion fitted with a reinforced rear seat, capable of carrying both passengers and goods (Howe & Davis, 2002). This form of public transport meets the majority of the population's transport needs and is gaining popularity in small SSA cities. For

instance, the number of the bicycle taxi fleet in Kisumu (Kenya) is around 10,000 operators, Nakuru city (Kenya) 6,000 operators (Mutiso & Behrens, 2011), Quelimane (Mozambique) 3,800 operators (Municipality_of_Quelimane, 2017) and Mzuzu (Malawi) 2,800 operators (Manda, 2014). However, bicycle taxi service is often demonized by transport authorities for their unfair road competition with other transport modes, power as a social pressure group, aggressive street behaviour for not respecting the basic traffic, and safety rules (Chilembwe, 2017; Manda, 2014; Mbegu & Mjema, 2019; Moyo, 2013). For the passengers, the bicycle taxi is highly popular for being accessible due to its low fares when compared to conventional modes of transport (Manda, 2014), flexible since it is a door-to-door means of public transport (Mendiate *et al.,* 2020), enabling following personalized passenger routes (Mbegu & Mjema, 2019). For the operators, bicycle taxi enables earning some family livelihood which contributes to reducing poverty. This service is easy to set up since few or no legal obligations are needed (Mbegu & Mjema, 2019), making the task of the regulation authorities even harder. For these reasons, identifying who the bicycle taxi operators are and their operating characteristics are crucial to promoting this sustainable means of non-motorized public transport.

Currently, there is limited literature on bicycle taxi service in African cities, with the few existing often focusing on the role of bicycle taxi as a means of public transport (Chilembwe, 2017; Jimu, 2008; Kipandula & Lampiao, 2015; Manda, 2014; Mbara & Maunder, 2003; Mbegu & Mjema, 2019; Moyo, 2013; Mutiso & Behrens, 2011; Pirie, 2011). This suggests the need for a deep understanding of who the bicycle taxi operators (BTO) are and what their main operation service characteristics are. This may help defining policies and strategies to regulate this means of public transport, thus making this service more sustainable. Two research gaps can be depicted: (i) Previous studies acknowledge the need for initiatives to promote the bicycle taxi as a means of public transport; however, these policies are often oriented to the entire population of BTOs (Mutiso & Behrens, 2011). Studies have proven that policies targeted at the entire population are ineffective since different groups of people have different needs (Anable, 2005; Bergström & Magnusson, 2003; Nkurunziza *et al.,* 2012). For this particular case of the BTO, most of them come from different spatial locations and the majority lack basic knowledge of road traffic rules. Such differences have an enormous impact on the operation characteristics, showing the need for more targeted policy initiatives. (ii) Overall, previous research has shown that although most BTOs present a similar socio-economic profile, there is a clear difference in their daily operation patterns (Manda, 2014; Mbara & Maunder, 2003; Mutiso & Behrens, 2011). Studies have pointed out that operation characteristics are influenced particularly by the capacity of overcoming competition from the other operators (Howe & Davis, 2002). This indicates that under such a service environment there are some prominent operators. This demonstrates the relevance of describing the operational patterns of people in different BTO groups. The absence of such analysis does not enable having a clear picture of which proportion of BTO is in need to be more motivated to keep bicycling for taxi service and promoting this sustainable means of urban public transport. This study thus attempted to fill these gaps.

Therefore, the objective of this study was to identify groups of BTO and their operation patterns in Quelimane, a medium-sized Mozambican city. To this end, clusters of bicycle taxi operators were assessed based on socio-economic factors. Their main service operation patterns were identified from their travel behaviour characteristics.

Materials and Methods

Case study description

Quelimane is the capital city of Zambezia province, the central province of Mozambique, (Figure 1). It is the fourth largest city in Mozambique with a population estimate of 349,842 inhabitants (INE, 2019) and with an area of 11646,97hectares. This city is the main commercial, administrative and education hub of Zambezia province. The city is divided into three district urban zones: The inner city (Z1), which concentrates most services and formal jobs, as well as the largest

markets. The city periphery (Z2), is mainly a low-income residential and mixed informal service area. This zone concentrates most informal markets. That is where bicycle taxis are very popular, mainly for enabling circulation in a poor road network environment, which creates difficulties for cars to circulate. The suburban area (Z3) is a farming zone. This area concentrates on rural constructions and agricultural areas.

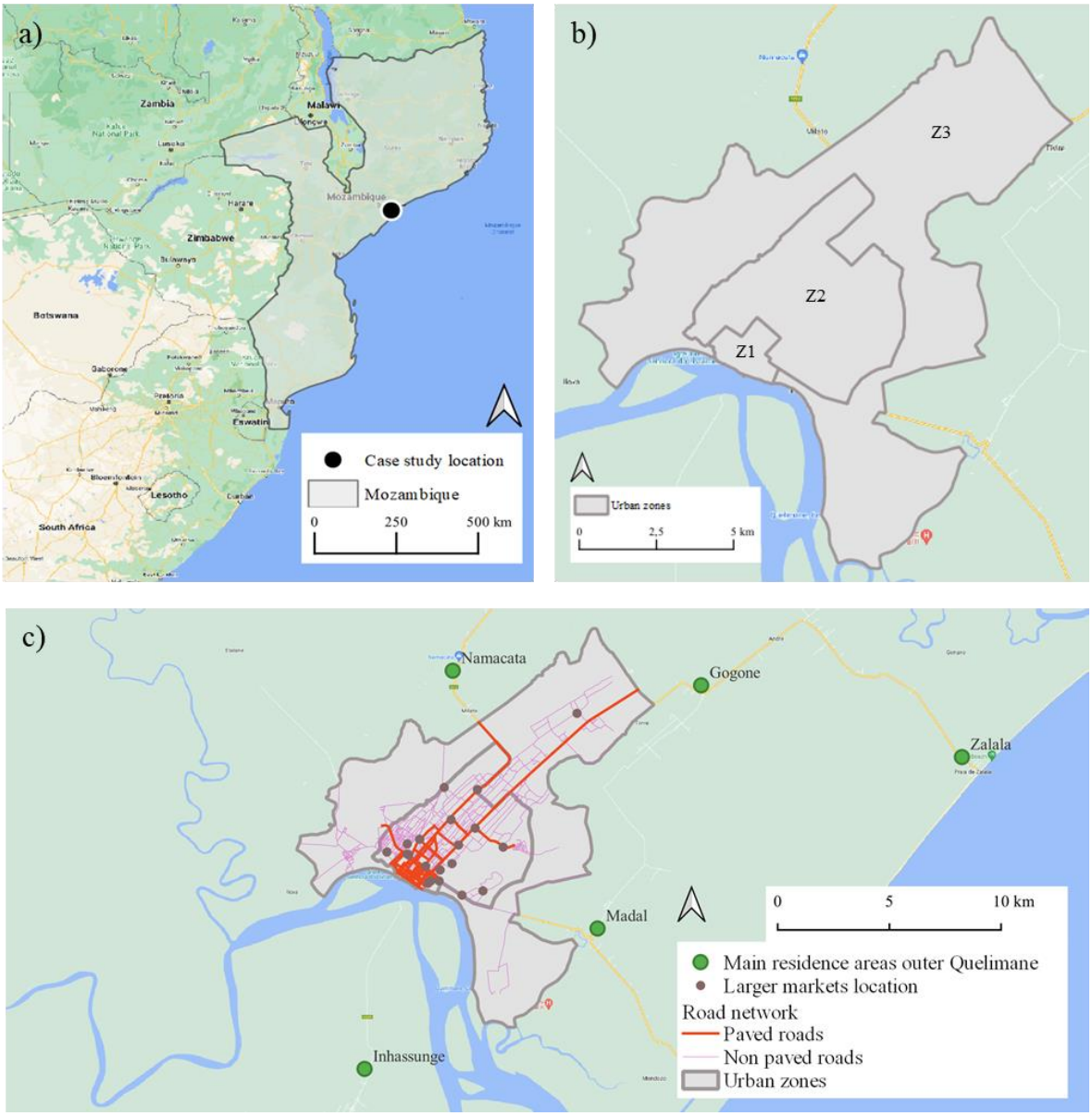

Figure 1. Case study location (a), urban zones (b), indication of road quality, large markets location and main residence areas neighbouring Quelimane (c)

Due to its function as the main urban centre in the province, this city has continued to attract a significant inflow of migrants that come in search of opportunities. However, the production of the opportunities that attract this population to the city has hardly kept pace with its inflow, thus making unemployment, poverty, and poor access to services a daunting planning challenge for the city authorities. Unemployment and poverty rates are estimated at around 46.3% and 49.2% of the city's total workforce and households respectively (Santos *et al.,* 2006). The bulk of this poor population resides in the slums and informal settlements of the city.

Regarding travel demand, Quelimane is a non-motorized city. Overall, walking (45%) and cycling (35%) represent the most popular modal shares (Mendiate *et al.,* 2020). It is worth mentioning that there is no convenient public transport in the city and bicycle taxi is the most popular means of public transport. There is an association of bicycle taxis at the municipality level, designated ATAMOZ (Mozambican Association of Bicycle Taxi Operators) and it was composed of about 3,584 in 2017 (Municipality_of_Quelimane, 2017). It is interesting to note that from all the operators, 1,284 (35.83%) come from the surrounding districts of Quelimane, mainly from Inhassunge, Namacata, Madal and Gogone. BTOs often concentrate on large bus stops and markets which are mostly located in the inner city, the city periphery and along the main road corridors. For these reasons this city was selected for this study.

Data gathering process

The empirical data used in this study was collected through a face-to-face interview survey. The survey was conducted between June and July 2021, and it was targeted only to bicycle taxi operators. They were intersected in large markets, bus stops, bus terminals and main bicycle taxi corridors. It was believed that these are places with high trip generation potentials, therefore BTOs are predominant. Bicycle taxi operators were randomly selected and a total of 105 BTOs were interviewed in less than 2 months. This corresponds to a level of confidence of 90% and a margin of error of 8% based on the universe of 3583 bicycle taxis registered at the ATAMOZ (Mozambican Association of bicycle taxi operators) (Municipality_of_Quelimane, 2017).

The survey collected information about standard socio-economic characteristics of the BTOs such as age, household characteristics, education level, income level, bicycle ownership and place of residence, Table 1. Gender was excluded since most previous studies have pointed out that all the bicycle taxi operators are male (Chilembwe, 2017; Jimu, 2008; Mutiso & Behrens, 2011).

The survey considered six socio-economic factors (age, income, education, household composition, bicycle ownership and residence location) characterizing the BTOs in Quelimane, Mozambique. Regarding age, 86.7% are young (<35 years old), followed by 10.5% adults (between 35 and 55 years old) and 2.9% elders (>55 years old) The most representative household type is couples with children (57.1%), followed by single living with other adults (19%) and single households (18.1%). 61% of the sample has only primary education and 37.1% have a secondary education level. Around half the respondents (50.5%) report earning an average monthly income of between 2000-5000Mts[1]. 67.6% of the respondents own a bicycle and 27.6% rent it. Regarding the place of residence, 49.5% of the sampled population reside in the sub-urban area while a remarkable 10.5% of the respondents reside outside the city.

The second section covers the bicycle taxi service operation patterns, which include the average number of daily passengers, average daily revenue and average service hours (Table 1). 54.2% of the sample of BTOs carry between 10-20 passengers per day, with an average of 16 passengers per day (95% CI= 14.81, 17.63). In regard to daily revenue, 55.2% of the sample

[1] MTs- Meticais (Mozambican currency)

population earn daily between 100-200Mts, average of 172.24Mts (≈USD 2.68) (95% CI=153.27,191.20). 81.9% of BTO work daily between 8-16h, average of 11.27 hours daily (95% CI=10.62, 11.92).

Table 1. Socio-economic characteristics of the sampled respondents

Socio-economic characteristics	n=105
Age	
% Young (<35 years old)	86.7
% Adults (>35-<55 years old)	10.5
% Elders (>55 years old)	2.9
Average monthly Income: 1 USD≈64.26MTS	
% Less than 1000Mts	8.6
% Between 1000-2000Mts	21.0
% Between 2000-3000Mts	50.5
% Above 3000Mts	20.0
Education level	
% Other levels of education	1.9
% Primary	61.0
% Secondary	37.1
Household composition	
% Single	18.1
% Single living with other adults	19.0
% Couple without children	5.7
% Couple with children or other adults	57.1
Bicycle ownership	
% Rent/borrow	27.6
% Own	67.6
% belonging to family or close relatives	4.8
Place of Residence	
% Inner city	1.9
% City periphery	38.1
% Sub-urban area	49.5
% Neighbouring districts	10.5
Service operating patterns	
Passengers carried per day	
% Less than 10	8.7
% Between 10-20	54.2
% More than 20	37.1
Average daily revenues	
% Less than 100Mts	9.5
% Between 100-200Mts	55.2
% More than 200Mts	35.3
Average service hours per day	
% Less than 8 hours	11.4
% Between 8 hours-16 hours	81.9
% More than 16 hours	6.7

Analytical procedure

Three analytical steps were taken to identify and profile groups of BTOs and their service operation patterns. SPSS version 23 was used to generate the database and for statistical analysis.

Step 1: Cluster analysis

Based on the socio-economic variables, age, income, and categorical factors household composition, education level, bicycle ownership, residence location, a Twostep cluster analysis to profile the existing homogeneous groups of BTO was performed. This clustering type was chosen for (i) handling both categorical and continuous data (Martínez *et al.*, 2006) and for (ii) automatically detecting the optimum number of clusters (Sarstedt & Mooi, 2014).

Of all the socio-economic variables used in the clustering; education level, household characteristics, bicycle ownership, age and place of residence present a strong discriminatory power among the clusters, while the rest of the socio-economic variables (Income level) included in the questionnaire did not improve significantly the quality of the clusters. The result of this analysis served as input to profile the service operation patterns of people in each group of BTO, Table 2

Table 2. Socio-economic profile of people in each cluster

Socio-economic characteristics	Less educated individuals in large households (24.8%)	Educated migrants (27.6%)	Less educated bicycle renters (18.1%)	Young operators in small households (29.5%)
Age	++	+	++	+++
% Young	65.4	89.7	94.7	96.8
% Adults	23.1	10.3	5.3	3.2
% Elders	11.5	-	-	-
Average Monthly Income (1 USD ≈ 64.26MTs)	+	+	+	+
% Less than 1000Mts	3.8	6.9	21.1	6.5
% Between 1000-2000Mts	26.9	20.7	21.1	16.1
% Between 2000-3000Mts	61.5	44.8	42.1	51.6
% Above 3000Mts	7.7	27.6	15.8	25.8
Education level	+++	+++	+++	+
% Other levels of education	-	-	5.3	3.2
% Primary	97.7	17.2	94.7	48.2
% Secondary	2.3	82.8	-	48.6
Household composition	+++	++	++	+++
% Single	1.2	0.9	42.1	35.5
% Single with other adults	0.7	3.4	21.1	48.4
% Couple without children	7.1	2.1	5.3	16.1
% Couple with children and other adults	91.0	93.6	31.6	-
Bicycle ownership type	++	++	+++	++
% Self-owned	98.7	62.1	2.5	87.1
% Hire/Borrow	1.3	37.9	97.5	12.9
Place of Residence	+	+++	+	++
% Inner city	-	3.4		3.2
% City periphery	34.6	31.0	57.9	35.5
% Sub urban area	65.4	27.6	42.1	61.3
% Neighbouring districts	-	37.9		-
n	26	29	19	31

Note: The marks on top of each socio-economic factors indicate within-cluster predictor factors importance. Where +++= high within cluster importance; ++=moderate within cluster importance and +=low within cluster importance.

Step 2: Testing the differences between service operation patterns considering the individuals in each cluster of bicycle-taxis-operators

After identifying clusters of bicycle-taxi-operators by socio-economic variables, a non-parametric test was conducted, to test the patterns of service operation differences between the clusters. Non-parametric tests revealed suitable for analysing data that are not normally distributed or are measured on an ordinal or interval scale (McCrum-Gardner, 2008) such as the present data. The tests of normality of the scores of the dependent variables show that the data do not assume the normal distribution as presented: Kolmogorov-Smirnov (K-S) = 0.163-0.190, df=105, Sig=0.000 and Shapiro-Wilk (S-W) = 0.685-0.916, df=105, Sig=0.000.The Mann-Whitney U test was employed for this purpose, mainly to compare two independent pairs of socio-economic clusters of BTOs based on a set of service operation variables such as the number of passengers carried daily, daily revenue and average daily service hours.. A total of 18 tests were conducted and the results indicated that at least one pair of socio-economic clusters of BTOs has the number of passengers carried daily/`daily revenues/service hours differ significantly from one another at p-level 0.05. The results are presented in Table 3.

Step 3: Comparing pairs of clusters of bicycle taxi operators with significantly different service operation patterns.

Then, from the Mann-Whitney U test results, those pairs of socio-economic clusters of BTO that present significant statistical differences at p-level 0.05, error bars were used to explore the existing service operation differences between them. Error bars are graphical representations of the variability of data and are used to indicate the error or uncertainty in a reported measurement. They often represent one standard deviation of uncertainty, one standard error, or a particular confidence interval (e.g., a 95% interval) (Field, 2013). The sample average scores of the service operation variables were used as a threshold to enable an easy assessment of the existing differences between the clusters. The results are presented in Figure 2.

Table 3. Mann-Whitney U test for differences in service operating patterns per pair of clusters of BTOs

a) Number of passengers carried per day			
	C1	C2	C3
C2	**0.007**		
C3	0.382	0.071	
C4	**0.022**	0.886	0.152

b) Average daily revenues			
	C1	C2	C3
C2	**0.023**		
C3	0.572	**0.008**	
C4	0.404	0.150	0.212

c) Average service hours per day			
	C1	C2	C3
C2	**0.009**		
C3	0.096	0.298	
C4	0.188	0.146	0.755

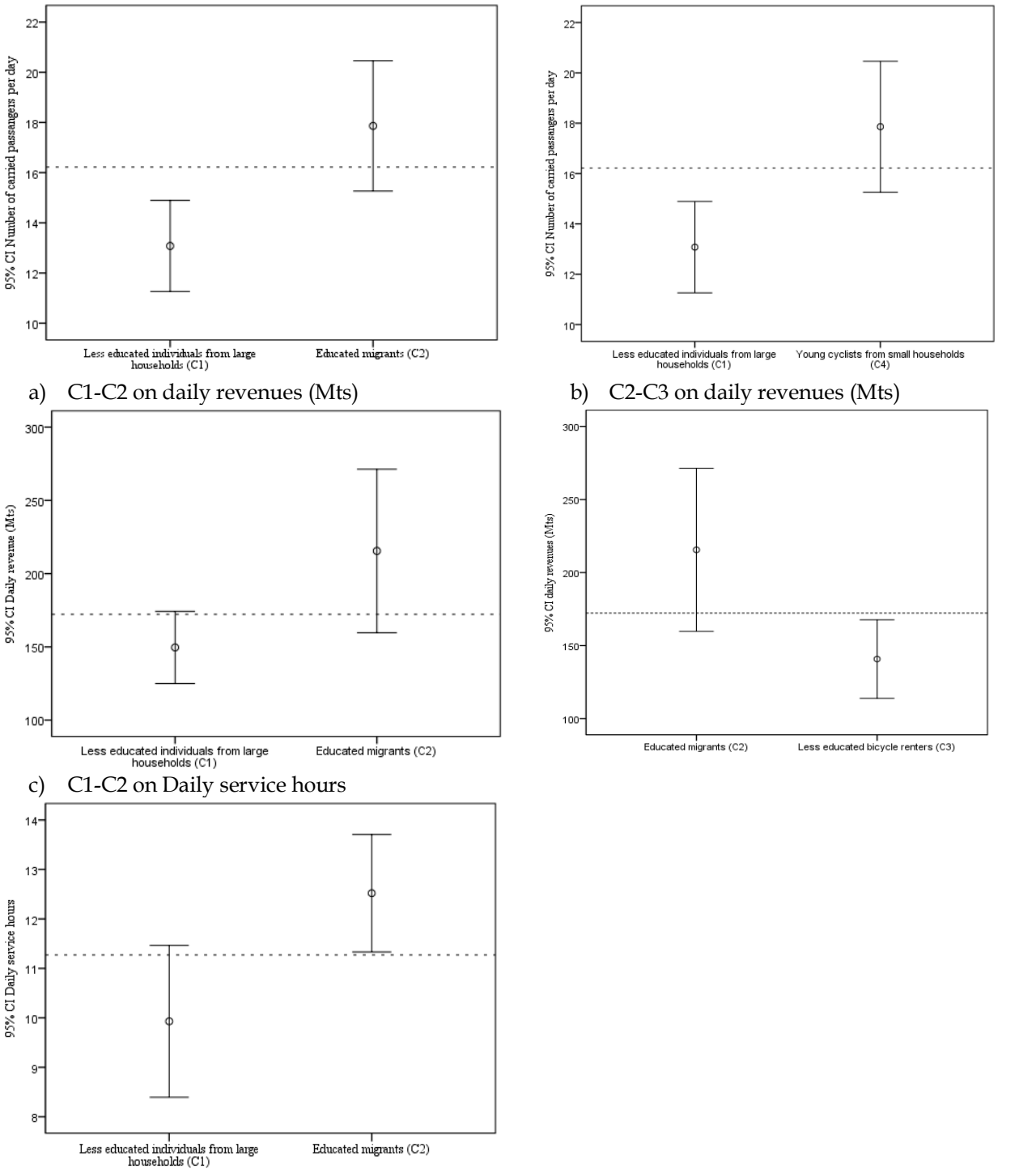

Figure 2. Main service operation differences between pairs of clusters of BTOs

Results

Within cluster predictor factor importance and socio-economic profile of clusters of BTOs

A total of six socio-economic factors were used as input variables of the Two-step Cluster Analysis. Based on the analysis, four clusters were selected, with a silhouette measure of cohesion and separation of 0.3, which indicates a decent quality of clusters. The smallest cluster contains 19 respondents (18.1%) while the largest cluster contains 31 respondents (29.5%). The overall predictor importance of the factors is: Household composition= 1, Bicycle acquirement= 0.96, Education level=0.66, Place of residence=0.33, Age=0.28 and Average monthly income =0.28.

Regarding the importance of each factor within the cluster, Table 2 shows that household composition and education level, present the highest importance within cluster 1 (C1). Therefore, this cluster was labelled as *less educated individuals from large households* since individuals surveyed were basically in households of couple with children and other adults and who had primary education levels. This cluster has a size that corresponds to 24.8% of the sample. In this cluster, 65.4% of people are young, 91% are couples with children living with other adults and 98,7% own bicycles. As for education, 97.7% of the sample respondents in this cluster have a primary education level, while 2.3% have a secondary education level. 65.4% live in the sub-urban area of Quelimane and 34.6% in the city periphery. Their average monthly income is around 2000-3000Mts.

On the other hand, Cluster 2 (C2) is the second largest, and has a size of 27.6% of the sample population. This cluster is highly influenced by the education level and place of residence and therefore it was denoted as *educated migrants* as it is composed mostly of individuals having an education level relatively above the mean (82.8% have a secondary education level) and residing outer of Quelimane city. Individuals in this cluster are young (89.7%), with an average monthly income between 2000-3000MTs. About 93.6% of the sample are from a household type of couples with children and other adults. This results in 62.1% owning a bicycle, although 37.9% still hire/borrow a bicycle for taxi activities. Most individuals in this cluster migrate daily to Quelimane for taxi service as 37.9% reside in neighbouring districts to Quelimane.

The third cluster (C3) comprises 18.1% of the sample respondents. This is the smallest cluster. The level of education and bicycle ownership are the most important factors. It was named as *less educated bicycle renters* since surveyed people present a low education level (primary level) and most rent a bicycle for taxi services. 42.1% of the individuals in this cluster live in households from single parents and 31.6% are couples with children and other adults. 94.7% are young and have a primary education level. 42.1% of the cluster sample present an income level between 2000-3000Mts. The majority do not own a bicycle as 97.5% hire/borrow one. 57.9% live in the city periphery whereas 42.1% reside in the sub-urban area.

Cluster 4 (C4) is the largest. It comprises 29.5% of the sample. Age groups and household composition as the most important variables defining the cluster. This cluster was labelled as *young cyclists from small households* for being composed mostly of young (96.8%) from households of single individuals living with other adults (48.4%). Regarding bicycle ownership, 87.1% own a bicycle and 12.9% hire/borrow one. Around 48.2% have primary education and 48.6% have secondary education. 61.3% reside in the sub-urban area whereas 35.5% reside in the city periphery. 51.6% of the people in this cluster have an average monthly income between 2000-3000Mts/month and 25.8% earn above 3000Mts/month.

Differences in service operation patterns between people in each cluster of BTOs

For each socio-economic cluster of bicycle taxi operators, the differences in the service operation patterns are assessed based on the number of passengers carried daily, average daily revenue and average daily service hours.

Regarding the number of passengers carried daily, it was observed that there are statistically significant differences between Cluster 1 and Cluster 2 (C1-C2; p=0.007), as well as between Cluster 1 and Cluster 4 (C1-C4; p=0.022) as

depicted in Table 3a. As for daily revenue (3b), verify that Cluster 1 and Cluster 2 (C1-C2; p=0.023), as well as Cluster 2 and Cluster3 (C2-C3; p=0.008) present statistically significant different service operation patterns. Moreover, for the average service hour, all the clusters present similar service hours except when comparing Cluster 1 and Cluster 2 (C1-C2; p=0.009) as seen in Table 3c.

Comparing pairs of clusters of bicycle taxi operators with significant statistical service operation pattern differences.

Figure 2 presents the comparison of service operation patterns between clusters of BTOs which present significant statistical differences after conducting the Mann-Whitney U test. Figure 2a) compares the average number of carried passengers between BTOs in C1 and Ce2. These results show that less educated individuals from large households (C1) carry on average 13 passengers per day (95% CI=11.26,14.89), while for cluster of educated migrants (C2) carry a much higher number of passengers of around 18 passengers per day (95% CI=15.26, 20.46). Moreover, individuals in C4, (Young bicycle taxi operators from small households) carry on average 19 passengers per day (95% CI=15.04, 22.06), which is a much higher number than 13 (95% CI=11.26, 14.89) from individuals in C1 see Figure 2b.

Looking at daily revenues, Figure 2c, indicates that individuals in the C1 (cluster of less educated individuals from large households) earn an average of 149.62MTs/day (95% CI=124.94, 174.29) whereas, individuals in the C2 (cluster of educated migrants) earn, on average, 215.52Mts per day (95% CI=159.74, 271.30). In addition, individuals in the C2 earn, on average, more (215.52Mts; 95% CI=159.74, 271.30) than those in the C3 (cluster of less educated bicycle renters) (140.79Mts; 95% CI=113.95, 167.63), see Figure 2d.

As for service hours (Figure 2e), statistically significant differences between those in the C1 and C2 is found. It is observed that those in C1 have an average service time of 9.93 hours (95% CI=8.39, 11.47) while individuals in C2 have a larger average of 12.52 daily working hours (95% CI=11.33, 13.71).

Discussion

This study contributes to identifying the existing clusters of bicycle taxi operators and their service operation patterns in the city of Quelimane. The clusters were identified through a Two-step cluster analysis based on the following socio-economic variables age, household characteristics, education level, income level, bicycle ownership and place of residence. Then the operating variables such as the number of passengers carried daily, average daily revenue and average daily service hours were first used to identify pairs of clusters with different operation patterns and later to identify the exact differences in service operation patterns between the clusters.

From Table 3, it is observed that for the number of bicycle taxi passengers, only BTOs in C1-C2 and C1-C4 present significant statistical differences. Based on Figures 2a and 2b, BTOs in C1 carry fewer passengers in comparison with those in C2 and in C4. This means that people in C1, produce fewer bicycle taxi trips when compared to the other clusters (C2 and C4). This can be explained based on Table 2, BTOs in C1 present the highest share of elder operators among the sample. This is consistent with previous studies which mention that, cycling declines with age (Fernández-Heredia *et al.*, 2016). Howe and Davis (2002) added that BTOs are mainly young males since this service is very physically demanding particularly in cities like Quelimane with bad road surfaces. This finding reveals that to increase the number of bicycle taxi trips and passengers carried, it is crucial to make this service more inclusive among people in different age groups. According to MWT_Uganda (2012) introducing tricycles and bicycles with gears could help to reduce the physical effort needed for the bicycle taxi service, particularly when cycling on bad road surfaces such as those in Quelimane. Therefore, to promote cycling in C1, it would be useful for policymakers to consider the above-cited factors especially if more elders are to be attracted into this activity, thus making this service more inclusive and promoting healthier communities.

Regarding daily revenues, only individuals in C1-C2 and C2-C3 present significant statistical service operation differences, Table 3. Based on Figures 2c and 2d, people in C2 earn more than those in C1 and those in C3. Based on Table 2, individuals in C2 present a higher education level than those in C1 and in C3. Howe and Davis (2002) mention that educated BTOs tend to establish a wider range of clients, thus more revenues. They offer better driving, following traffic rules. They also present better appearance and even personal hygiene, and are less abusive and less arrogant with the passengers, specifically with women. Moreover, they are sometimes equipped with a mobile phone and allow payment with digital platforms. The findings of this study suggest that to increase the revenues among BTO in C1 and C3, it is crucial promoting campaigns to increase the overall educational level of BTOs and improve the quality of the service provided to the passengers, which could obviously increase demand for this service. Consistent with Alonso et al. (2018), safety and accessibility to taxi services are highly valued by frequent taxi users. Therefore, to increase revenue among BTOs in C1 and C3, policy initiatives aimed at increasing the quality of services can be focused on providing basic knowledge of traffic rules, increasing passengers' safety and massifying the use of mobile phones among the BTOs to enable easy reach, reduce users waiting time and increase accessibility to these services.

Based on Table 3, only BTOs in C1 and C2 present statistically significant differences in service hours. Figure 2e shows that individuals in C2 present longer service hours than those in C1. Table 2 implies that C2 has a higher proportion of BTOs that hire/borrow a bicycle from friends or family. In line with Mutiso and Behrens (2011), individuals hiring a bicycle tend to maximize the opportunity, thus cycling long hours, which could have a negative impact on their health, as reported in a previous study (Kipandula & Lampiao, 2015). This finding suggests a clear need of making bicycles more accessible which could contribute to reducing the need for long cycling hours in response to the opportunity of borrowing bicycles for this service. Evidence by MWT_Uganda (2012) and Nkurunziza et al. (2012) show that assisting people with credit schemes, lowering bicycle purchase taxes is likely to increase bicycle ownership per household, with resulting benefits for the economy. This indicates that measures to reduce the overall bicycle taxi service hours should be focused on making bicycles more accessible, particularly if to target those that do not own a bicycle for this service.

Conclusion

The results of this study helped to define appropriate policy strategies targeted to increase the level and quality of the bicycle taxi service in the city. In this study, four clusters of bicycle taxi operators were found from six socio-economic variables: age and average monthly income, education level, household composition, bicycle ownership and place of residence. These clusters exhibit different service operation patterns. These clusters were labelled as less educated individuals from large households (C1), educated migrants (C2), less-educated bicycle renters (C3) and young cyclists from small households (C4). When comparing differences in the service operation patterns, it is observed that for the number of passengers carried daily, only C1-C2 and C1-C4 present statistical service operation differences. Individuals in C1 transport fewer passengers per day than those in C2 and C4. They can be motivated to cycle more for this service by reducing the physical effort needed for the bicycle taxi service operation. When looking at the daily earnings, only BTOs in C1-C2 and C2-C3 present significant statistical differences. Individuals in C2 earn more than those in C1 and in C3. Therefore, to increase daily revenue for people in C1 and C3, educational campaigns could be an appropriate policy measure to enable operators to improve their levels of service, thus increasing the range of passengers and daily revenues. Regarding daily service hours, only individuals in C1 and C2 present statistically significant differences, whereas BTOs in C2 present long service hours daily. Cycling long hours is harmful to health, for this reason, it would make sense to promote financial schemes to increase bicycle purchase, ownership and reduce the dependency on borrowing/hiring bicycles for taxi services.

The results of this study constitute an initial attempt to identify clusters of BTOs and bring

light into their service operation patterns. Since the study has shown that bicycle taxi operators can be motivated differently to improve the quality of the service provided, further studies should explore the link between each cluster of bicycle taxi operators and psychological factors towards the quality of this service. This information will help to have more predictable service operation patterns.

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