Urban Travel Demand Analysis: A Case Study of Maputo, Mozambique

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Abstract: The demand for transport has been increasing more rapidly in developing cities. Rapid economic growth, poverty problem, and less organized bus systems characterize the usage of each mode. This paper tries to investigate the urban travel demand in Maputo and to explore the contributing factors. Using person trip survey data, the urban travel demand is investigated through aggregate travel demand mode. Model results show that household attributes have a significant influence on the travel demand in Maputo.

Keywords: Person Trip Survey Data, Travel Demand, Aggregate Demand Model

1. INTRODUCTION

The demand for transportation has been increasing more rapidly in developing cities such as Maputo. Rapid economic growth, urbanization, poverty problem, coupled with less organized bus systems characterize the usage of each transport mode. In a study on the poverty and the urban transportation in East Africa, Howe et al. (2000), found that the rapid and continuing population growth has been accompanied by an equally rapid increase in the demand for public transport. They argue that this is not only because of the increase in the number of users, but also the increasing commuting distances resulting from the expansion of the cities. For Howe et al. (2000), the expansion of the cities makes the non-motorized transport modes less attractive, whilst the private car usage is the prerogative of the wealthy minority.

Despite the increasing demand for transportation in Maputo, factors influencing the demand for transport have not yet been fully studied. However, understanding the factors influencing the demand is critical to reducing the growing gap between the demand and supply sides.

1.1 Objectives of the study

The rapidly growing demand for transport provides an excellent opportunity to promote public transport usage. The usage of public transport will, in turn, can benefit not only the environment but also the public transport operators by reducing the vulnerability of services due to subsidy irregularities. Given this background, the goal of this paper is to investigate the urban travel demand and the contributing factors. To achieve this goal we use person trip survey data conducted in Maputo City by Japan International Cooperation Agency (JICA) in 2013.

1.2 Research structure

The paper is organized as follows. In section 2, previous studies are reviewed to identify the factors commonly found to influence the demand for transport in developing cities. In section 3 we begin with a brief historical review of the urban bus system in Maputo. The historical perspective provides a background to better understanding the current travel patterns in the study area. Furthermore, section 3 also describes the attributes of the households and their trip behavior. In sections 4 and 5, we briefly summarize the sample data and the modeling approach. Section 6 presents the model results and their implications. Finally, the conclusion is presented in section 7.

2. LITERATURE REVIEW

Travel demand analysis has long been an active research area. Early efforts to estimate travel demand resulted in what is commonly known as Urban Transportation Modeling System. McFadden and Domencich (1975) state these traditional demand models were primarily developed to forecast the effect of long-term changes in population demography on the travel demand. However, the models fail to recognize that travel decisions represent optimizing behavior by the commuters. These authors argue that the ability of a travel demand model to forecast accurately the effects of policy changes requires that it be causal, by establishing the behavioral link between the attributes of the transportation system and the decisions of the individuals. McFadden and Domencich (1975) illustrated this link by developing theories of individual and population travel demand behavior. Under these theories, the consumer is assumed to have a utility or satisfaction function defined on both consumption and transportation attributes.

In order to proceed with the review, it will be useful to consider what is generally meant by travel demand. According to Kanafani (1983), the needs for transportation results from the interaction between social and economic activities dispersed in the space. As result travel demand is defined as the process of relating the demand for transport to the socioeconomic activities that generate it. For Small et al. (2007) the approach most similar to the standard analysis of the consumer demand is the aggregate one. Under the aggregate demand model, the travel demand is explained as a function of variables that describe travelers or the modes of transport. Likewise, a commuter or group of commuters are also assumed to maximize a utility function subject to budget constraints.

Ortúzar et al. (1990) studied the vicious cycle between the car and public transport. They state that the economic growth provides the first impetus to increase car ownership. For Ortúzar et al. (1990), more car owners mean more people aiming to shift from public transport to private car. With fewer public transport passengers, public transport operators may respond either by increasing the fares or reducing the level of services or both. However, according to Ortúzar et al. (1990), these measures make the usage of the private car even more attractive than before and may induce more people to buy cars, thus, inducing the vicious cycle. Furthermore, they emphasize that in mid-or-long terms car users face increased level of congestion, whilst buses are delayed and running less frequently.

Several studies have been conducted also in the context of developing countries. For example, Barter (2000) put forward a mechanism to describe motorization phenomena. Known as simple generic model of the urban transport and land use evolution in developing cities, the model is intended to describe the paths taken or potentially to be taken by cities in the developing world. Following Barter (2000), some cities in Asia have moved rapidly from

transport systems in which walking, non-motorized vehicles and rudimentary, low-cost, bus-based public transport systems catered for the majority of transport needs, to a situation where cars and motorcycles are beginning to dominate. Barter (2000) underlines that these outcomes are influenced not only by the decisions of individual consumers but also by governments policies towards motor vehicle ownership and use, road supply, urbanization and suburbanization, traffic restraint and relative investments in roads, public transport, and non-motorized modes.

According to Vasconcellos (1997), misunderstandings have occurred in the studies on the demand for transport in developing countries. Vasconcellos (1997) argues that the economic view of the car as a "free consumer desire" is inadequate to understand the context of developing countries. Due to market failures, the majority of people in the developing countries have no choice than to use public transport. Vasconcellos (1997) states that in addition to its utility, the demand for private cars is influenced by urban, transport, and economic policies which shape the space and constraining transport choices.

On the other hand, Kutzbach (2009) analyzed the rise in car use and the decline in bus services in developing countries. He states that although empirical evidence at the country level may suggest a strong relationship between the rising income and car use, at the urban level, local characteristics, traffic congestion, and policies do affect travel decisions. He highlighted the positive feedback between traffic congestion and car use as leading to deterioration of bus services.

ITO et al. (2013) also examined the general mechanism of motorization in the Asian developing mega-cities. Their findings show that motorization is influenced mainly by economic growth and urban structure change. According to ITO et al. (2013), initially, car ownership rises due to economic growth. Then, car ownership growth enhances the convenience of movement and accelerates the expansion of the urban area to suburbs. Dargay et al. (1999) used historical data for more than three decades worldwide and found a strong relationship between the growth of per-capita income and the growth of car ownership levels. Car and vehicle ownership are expected to continue growing as income per-capita increases. Fujiwara et al. (2007) investigated the motorization in terms of passenger cars and motorcycles in the Asian context. Their findings indicate that motorization is increasing rapidly in the Asian context. With the introduction of competition by Chinese and Indian car producers in the market, the authors expect an acceleration of motorization in Asia.

One of the most informative literature on the travel demand in the context of developing countries is the public transportation in developing countries by Iles (2005). According to Iles (2005), the supply of public transport in developing cities is determined by various demographical, environmental, institutional, and economic factors. The author states that population density, the distribution, and growth are three important factors determining the demand for transport. A serious demographic problem in developing countries is the rising migration of the population from the rural areas to urban areas, which leads to rapid and often uncontrolled growth in urban areas. Secondly, economic factors include low levels of Gross Domestic Product, GDP per capita, uneven distribution of income, both demographically and geographically, fluctuations in the world commodity prices, and poor availability of foreign exchange. Developing countries are characterized by a highly skewed distribution of income, with a large majority of the population receiving low incomes, and a small minority earning very high incomes (Iles, 2005).

Finally, Iles (2005) states that the conditions of the road network in developing cities both paved and unpaved, contributes to congestion, reducing the speed, profitability, and useful life of public transport vehicles. The author emphasizes that the coverage of the road network limits the reach of bus services, and promote the use of minibuses, taxis, and

motorcycles, which have greater maneuverability than large buses but are not efficient as means of the urban mass transportation.

3. FUNDAMENTAL FEATURES OF THE CITY

3.1 Background

Maputo is the capital city of Mozambique in the southern Africa region (Fig.1). With a population of approximately 2.3 million people (as of 2012) and an area of 1,228 km^2, Maputo is the economic center of the country. The city was established as a main urban center in early 1884 with the development of road and railway infrastructures respectively, which connect Mozambique and South Africa.

Fig.2 shows the characteristics of households. According to Howe et al. (2000), East African cities can be considered "young cities" with a substantial proportion of the population being the first generation of the urban dwellers. From fig.2, Maputo appears to fit in the category of "young cities" with the majority of the household members below 40 years old. In addition, household composition is characterized by a large number of members, with most of the households having at least 6 members. Occupation status figures provide information required in order to understand travel behavior patterns. As shown in fig.2, the ratio of unemployed, housewives and students, is at 64%. They comprise the category of the low-income group making fewer trips than the other groups.

Occupation status figures provide information required in order to understand travel behavior patterns. As shown in fig.2, the ratio of unemployed, housewives and students, is at 64%. They comprise the category of the low-income group making fewer trips than the other groups. The proportion of employment in the informal sector at 18.4%, is greater than that in the formal sector (12.25%). The informal sector in this study includes street vendors, merchants, and own account workers. Poverty problem is the main reason for the rapidly growing informal sector. Other reasons include lack of jobs, higher birth rates and migration from rural areas to the capital city. The combination of these socioeconomic characteristics contributes to a more complex travel behavior patterns which are discussed later.

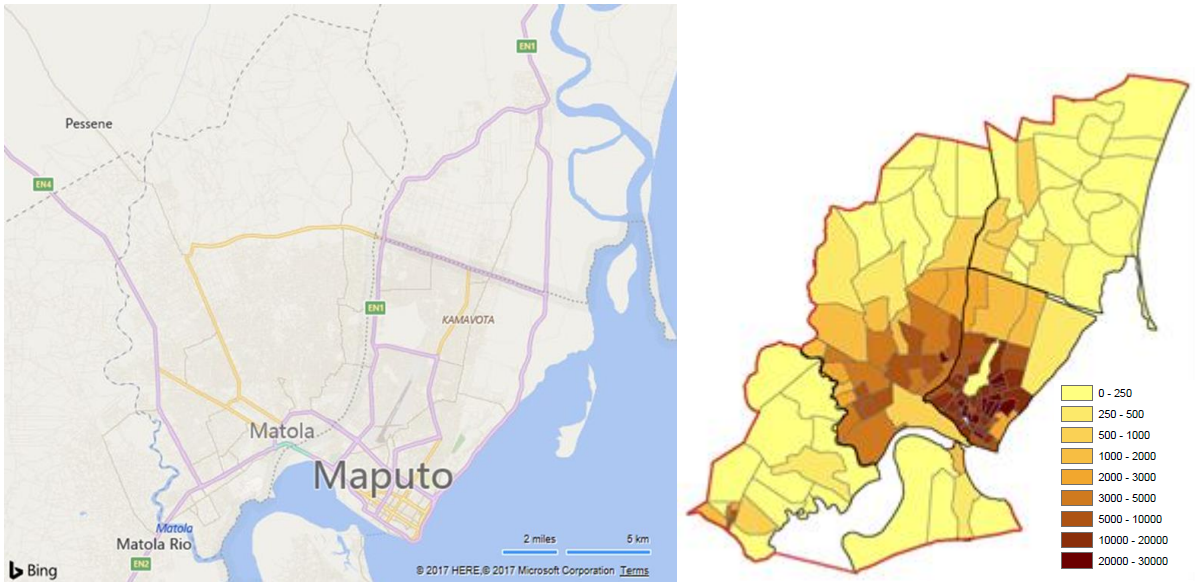

Figure 1. Population density per zone in Maputo (source: Bing map and JICA, 2012)

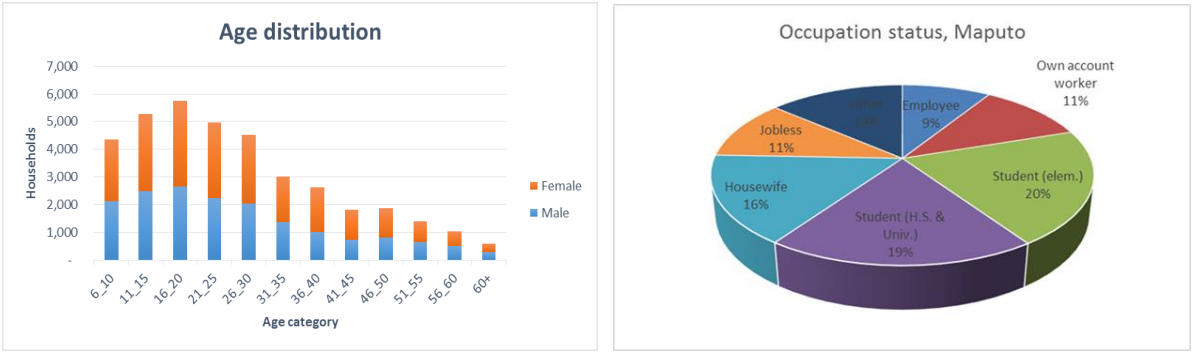

Figure 2. Household characteristics

3.2 Urban transportation

Mozambique is an independent country since 1975. At the beginning, the urban transport services were provided by a state-owned bus company *"Transportes Urbanos de Maputo"* under a government regulated monopoly system. Fares were regulated to ensure affordability of the majority of the population. However, as the operating costs increased over time and subsidies did not the company experienced difficulties to expand bus services. Fig. 3 shows the number buses owned and operated by the company. For example, less than half of the buses owned are available to service the demand. As a result, the patronage gradually declined from 60 million users in the 1970s to 10 million in the 2000s.

Due to the growing demand unserved by public bus operators, individuals initiated the paratransit services and gradually their number increased. These new minibus operators were formally acknowledged as transport operators in the end of 1980s when the government gave them permission to operate public transport services. This yielded to the development of minibus "chapas" industry. The designation "chapa" is due to the flat fare system, that is, transport fare was fixed irrespective of the distance traveled. By the beginning of the 1990s "chapa" operators had a significant share of the market.

At the present, little has changed both public bus and individual "chapa" operators continue to be the main providers of the urban transport services. With respect to the capacity of the vehicles, this ranges from 15-to-25 passengers for "chapas", and a minimum of 50 passengers for the public buses. It is worthy to note that other transport modes such as railway and ferry services are also available but their market share is insignificant. Buses and minibuses "chapa" share most of the routes. However, due to supply-side limitations, the number of the routes of the public buses (59 routes) is smaller than that of the minibuses (139). JICA (2013) estimates the total daily trips as of approximately 3.6 million trips.

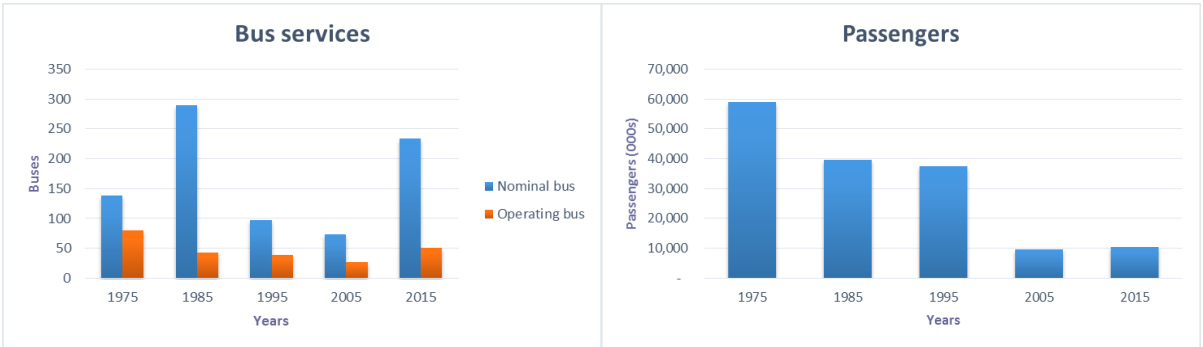

Figure 3. Public bus services in Maputo, 1975-2015 (source: Maputo city, 2012)

Figure 4. Public buses and “chapas” in Maputo
Source:https://www.google.com/search?q=transporte+publico+em+maputo

Baker et al. (2005) state that relatively little is known about travel behavior of the urban poor in the developing countries, their residential patterns, and how these are affected by transport policy. In this study, we assume that rapid economic growth, poverty issues, and less organized bus systems, characterize travel patterns and the use of each mode in the study area. Over the last decade, Mozambique has been experiencing rapid economic growth. The rapid economic growth not only increased the movement of people and goods but also contributed to rapid expansion of the city to a metropolitan area of about 2.3 million people (as of 2012). Because the majority of the population living in Maputo are poor, most of the people are forced to live in further suburban areas where housing costs are affordable. However, as it would be expected, bus services are poorly provided in the outlying areas. For example in 2012 road network coverage in Maputo city was at about 1001 km, of which only 359 km, that is, 38%, comprise paved roads whilst the remaining 642 km (64%) of the of the road are unpaved roads. Likewise, outlying areas have 714 km of total road network, but only 187 km constitute paved roads

According to JICA (2012), some people have to walk up to seven kilometers to access bus routes. This, however, is not surprising because buses usually follow the road network (see fig.1) and their service area is limited. Table 1 illustrates travel demand characteristics. As shown in table 1, walking dominates trips by gender (67-75%), followed by minibuses “chapas” (15-17%), and private car (14-6%). For the age group category, a substantial proportion of young people makes trips by walking. This group comprises mostly unemployed and elementary and secondary students.

To further understand the travel demand in Maputo we should also consider operators’ behavior. We begin by looking to the “chapas” operators. The majority of the operators of the “chapas” are not the owners of the vehicles, but hired drivers. They are hired under 3 main conditions: (1) to pay a daily fixed amount of revenue to the owners of “chapas”; (2) to meet their own salary and (3) to provide for the daily operating costs. On the other hand, minibus drivers usually hire a conductor who collects the fares from the passengers. There are no formal contracts either between the owners and the drivers of “chapas”, or, between drivers and conductors. Under this scenario, minibus operators attempt to maximize their revenues either by minimizing maintenance costs of “chapas” or by maximizing the daily trips. It is likely this crew behavior underlining the low rating of the levels of services by commuters (fig. 5). Finally, public bus operators have a fleet of about 400 conventional buses, but less than 50% of buses are operated. A substantial proportion of buses is out of services due to delays in the acquisition of spare parts and mechanical problems. Some buses are “cannibalized” to provide parts for others, and very often the buses which are “cannibalized” are rarely returned to service.

Table 1. Travel demand characteristics

	Walking	Minibus	Bus	Car	Others
Gender					
Male	67.49	14.52	1.78	13.70	2.51
Female	75.39	16.54	0.77	5.76	1.53
Age group					
19 or less	89.05	7.57	0.21	1.60	1.57
20-29	62.43	25.69	1.49	8.31	2.07
30-39	58.19	23.71	1.75	13.92	2.43
40-49	56.94	21.80	1.29	16.68	3.28
50-59	53.42	22.82	2.04	17.68	4.04
60 or more	63.62	19.43	1.49	13.33	2.13
Purpose					
Home	72.83	17.76	1.06	6.27	2.07
School	86.00	8.07	0.26	3.02	2.65
Work	54.53	21.47	1.56	18.16	4.29
Business	56.21	22.78	1.18	17.46	2.37
Send/pick	57.33	17.74	0.77	22.62	1.54
Leisure	68.51	20.74	1.35	8.58	0.82
Other	67.67	19.76	0.91	10.61	1.06
No. of trips	38781	6969	412	3249	785

Table 2. Tabulation of transport mode by location

Transport mode * Location						
			Zone			Total
			CBD	Maputo city	Metropolitan area	
Transportation mode	Bus	Count	3	74	69	146
		% of Total	0.0%	0.3%	0.3%	0.6%
	Car	Count	250	826	509	1585
		% of Total	1.0%	3.2%	2.0%	6.2%
	Minibus	Count	64	1505	1008	2577
		% of Total	0.2%	5.8%	3.9%	10.0%
	Other	Count	28	250	208	486
		% of Total	0.1%	1.0%	0.8%	1.9%
	Walk	Count	369	11003	9586	20958
		% of Total	1.4%	42.7%	37.2%	81.4%
Total		Count	714	13658	11380	25752
		% of Total	2.8%	53.0%	44.2%	100.0%

Table 2 describes the mode choice per zone. For a better understanding, the information provided in table 2 should be complemented with the reasons for mode choice in fig. 5. For Non-motorized transport, the proportion of people relying on walking in the CBD (1.4%) is far lower than that in the city and metropolitan areas. Likewise, for public transportation, “chapas” are the more popular mode in the city and suburban areas. For mode choice reasons,

comfort, travel time, and convenience are commonly known to have an influence on the mode choice decisions. However, these appear to have little impact in Maputo. This finding is consistent with Vasconcellos (1997). He argues state that majority of people in developing countries are left with no choice due to market failures. Under the category of the car users, three main reasons such as comfort, convenience, and travel time seem to influence car usage. Private cars are by far more comfortable and convenient than both buses and "chapas" which are always crowded in the peak-hour periods.

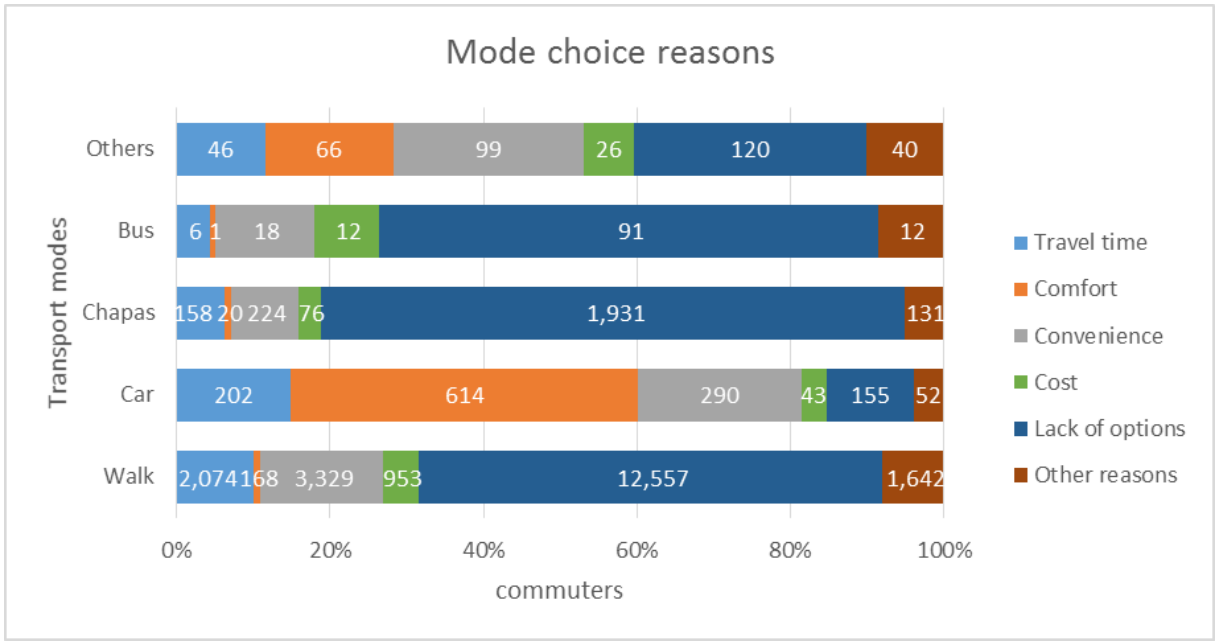

Figure 5. Factors influencing mode choice by commuters in Maputo, 2012

3.3 Trip distribution

Fig.6 provides some insights to understand the temporal distribution of trips. Unlike the commonly two peak-hour periods found in many cities worldwide, the temporal distribution of trips in Maputo is characterized by three peak-hour periods, namely, at 6 a.m. and 5 p.m. and between 10 a.m. and 1 p.m. respectively. This pattern might reflect the socioeconomic characteristics of the city. First, most of the households comprise a higher ratio of unemployed, elementary and secondary school students, and the share of people engaged in the informal sector. A substantial proportion of household members has employment in the informal sector. As it would be expected, activities in the informal sector do have a flexible schedule which may affect travel patterns. According to Howe et al. (2000), the increasing importance of the informal sector activities as a source of income in the developing cities is changing the nature of travel behavior. These authors state that even though commuting peaks remain, they are overlaid in both space and time by more complex irregular movements associated with trading, hawking and employment-seeking. In the case of Maputo, other contributing factors shaping this pattern of peak-hour periods are trips to and from school. Schools have three distinct starting time periods: at 6:30 a.m., 12:00, and 5:30 p.m. respectively.

Lastly, fig.7 shows trip length by different modes. As it would be expected as commuting time becomes longer, walk trips are less attractive. Unlike many cities worldwide,

the majority of commuters who cannot afford transportation costs usually spend more than 60 minutes walking in order to access their destination. This, however, is not surprising considering that Mozambique is one the poorest countries in the world. This figure is further exacerbated by the use of "full-dispatching principle". According to Iles (2005), in many developing countries buses wait at the terminal until they have enough passengers and then departure.

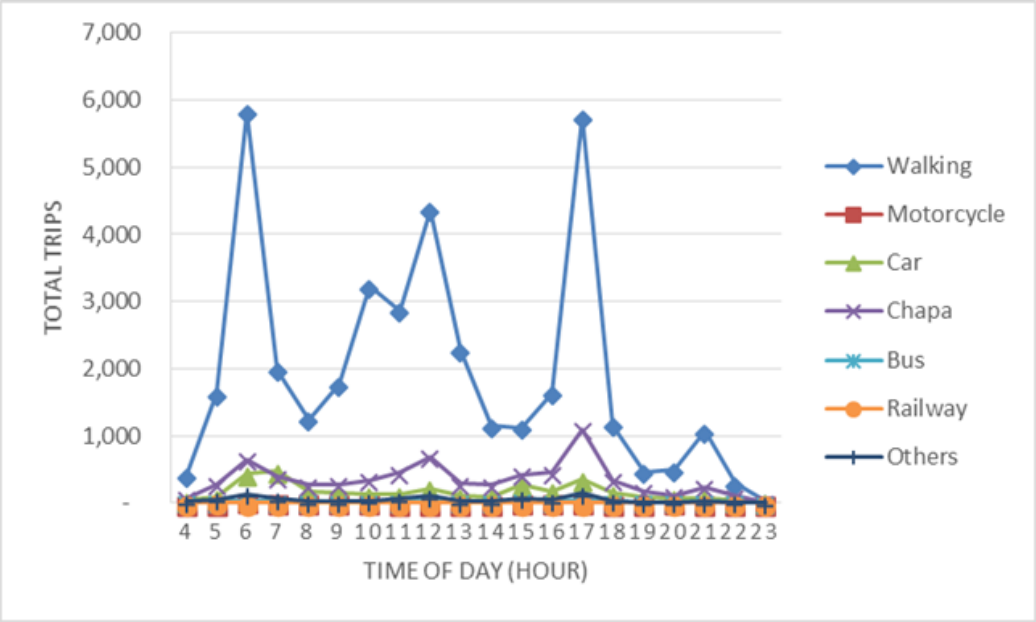

Figure 6**:** Temporal distribution of trips in Maputo, 2012

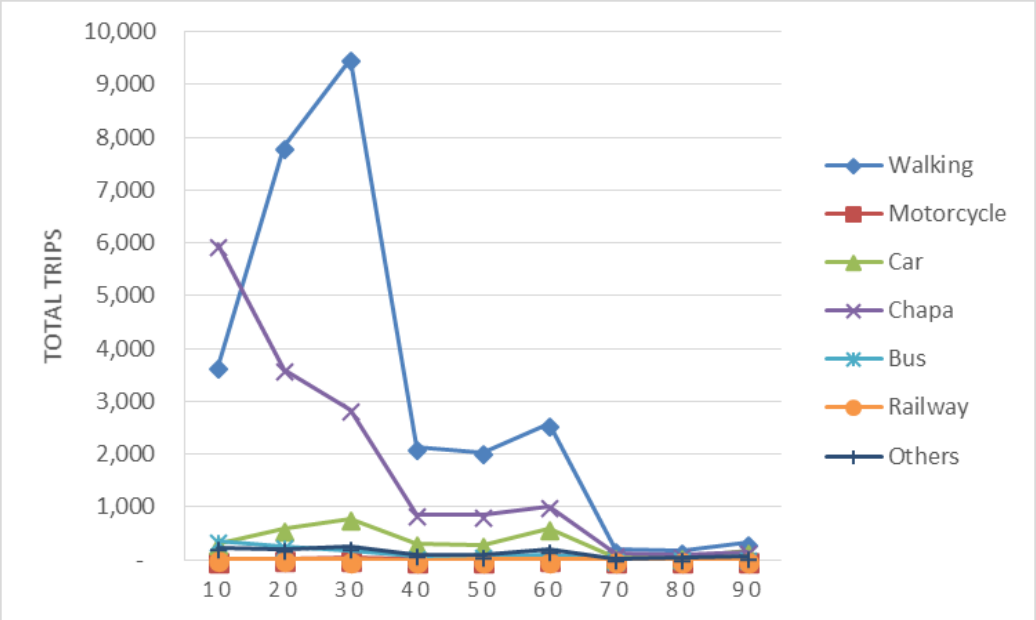

Figure 7**:** Modal share by trip length in Maputo, 2012

4. DATA

We used data from person trip data conducted in 2012, in Maputo. Person trip data consists of the information on the socioeconomic characteristics of the households and their trip behavior in the previous 24-hour period. The sample characteristics are summarized in table 3.

Table 3. Person-trip data sample

Attributes	
Number of the households	9983
Number of household members	37900
Total of households owning car	1191
Total daily trips	50196

5. AGGREGATE TRAVEL DEMAND MODEL

5.1 Model description

Dargay *et al*. (2006) state total daily mobility reflects the individual's choices of daily out of home activities, or the resources spent to pursue a series of activities. Dargay et al. (2006) argue that travel demand can be measured in terms of trips, distance, or time spent traveling. On the other hand, Small et al. (2007) that total travel demand is explained by a vector of all the relevant characteristics of the transport mode and the commuters. Although the approaches seem similar, in this study we adopt the approach used by Dargay et al. (2006) given the data availability. Therefore, the travel demand is herein represented as:

$$Y = (X, V, u) \tag{1}$$

where,

Y : number of trips by public transport
X : attributes of household or individual
V : private car ownership
u : error term.

The X variables include all relevant attributes of households assumed to influence travel demand. Household composition, gender, age, and occupation were considered. Vehicles owned by households are included in the V variable. The error term is assumed to be representative of the other variables not included in the model, but are likely to influence travel demand.

5.2 Correlation analysis

Bilal et al. (1997), correlation analysis is a measure of the degree to which the values of these variables vary in a systematic manner. The analysis of scatter plots (fig. 8 to fig.10) shows a moderate correlation and a non-linear relationship between the variables. Therefore, we employ a natural logarithm model which allows the coefficients to be interpreted as elasticity.

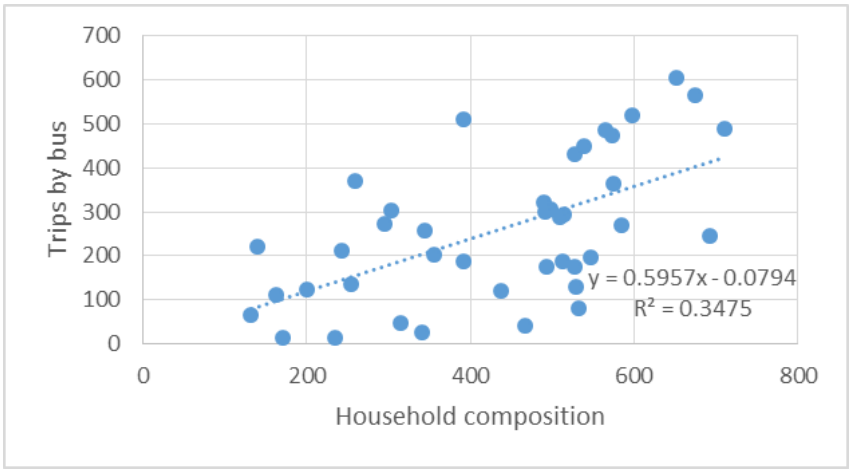

Figure 8. Trips by bus versus household size

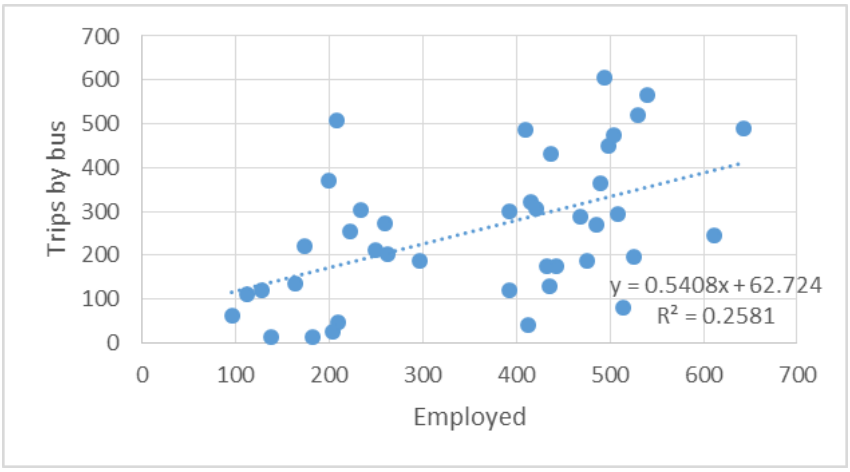

Figure 9. Trips by bus versus the employed

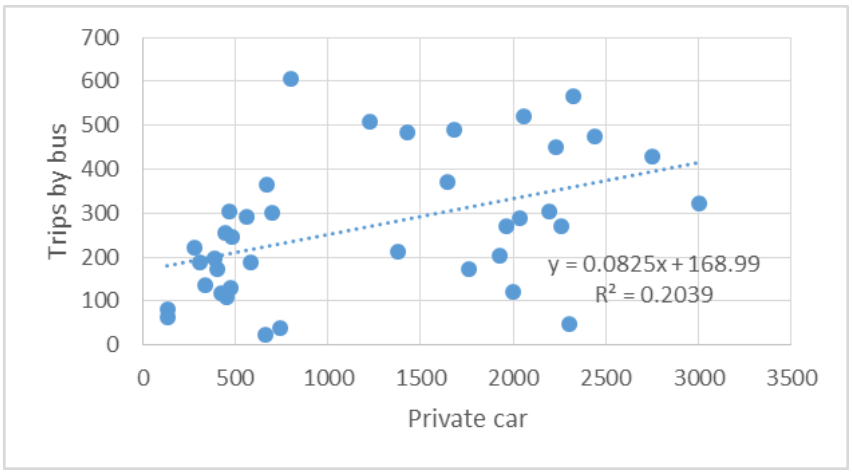

Figure 10. Trips by bus versus private car ownership

6. MODEL RESULTS

In this section, we apply regression model based on the discussion of the previous section. In order to capture the factors that influence travel demand, we estimated the aggregate demand model using person trip survey data. Estimation results are shown in tables 4, 5, and 6, respectively. The indicators from tables show that the model is appropriate and a good fit. The R^2 value is 0.89 implying that the independent variables are able to explain 89% of the variation in the dependent variable. The signs of the coefficients of independent variables not only are in accordance with the travel demand theory, but they also are individually statistically significant at least the 1% significance level. Collectively all the explanatory variables are statistically significant, for the estimated *F value* of 261 has a *p value* of almost zero. Therefore, we can safely reject the null hypothesis that all the coefficients are simultaneously equal to zero.

From table 6, household compositions (HH size), employment status, and car ownership have an impact on the demand for transport. Holding all other variables constant, increases in the household composition (size) contributes positively to demand for transport. Household sizes tend to be large mostly due to high population growth rate. This finding is consistent with reviewed literature where increases of the urban populations lead to rising demand for transportation. Likewise, *ceteris paribus*, an increase of the employed have a positive impact on the demand for public transport, which may not be a surprising result.

Lastly, household car ownership and trips by bus are negatively correlated. With the growth of car ownership and use, the trips made by buses diminishes. The negative influence of car ownership on the bus system may contribute to perpetuating the social exclusion of the "captive" users of bus services.

Table 4. Model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.944[a]	.891	.887	.4855
a. Predictors: (Constant), ln(Car), ln(HH size), ln(Employed)				

Table 5. Analyze of Variance

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	184.358	3	61.453	260.680	.000[b]
	Residual	22.631	96	.236		
	Total	206.990	99			
a. Dependent Variable: ln(Trip)						
b. Predictors: (Constant), ln(Car), ln(HH size), ln(Employed)						

Table 6. Model estimation results

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.937	.454		-4.264	.000
	ln(HH size)	.553	.052	.668	10.595	.000
	ln(Employed)	.959	.234	.668	4.103	.000
	ln(Car)	-.354	.142	-.375	-2.498	.014
a. Dependent Variable: ln(Trip)						

7. CONCLUSION

The demand for public transportation has been growing more rapidly in developing countries. Rapid economic growth, poverty problems, coupled with less organized bus systems characterize the use of each mode. Using person trip survey data, this paper investigated the urban travel demand in Maputo by applying aggregate demand model.

Findings suggest the household characteristics including the composition of the households, the number of employed people and car ownership, as the factors influencing the demand for transport. This implies that with increasing number of households with large members coupled with a rise of the employed, the pressure on the urban bus system is expected to increase. In the context characterized by poorly organized bus system as is the case in Maputo, the negative impacts of the household car ownership and use on the bus services is expected to contribute to the deterioration of public transport services, thus, social exclusion. This is because the majority of people are poor and depend on the public transport for commuting purposes. Based on these findings, we suggest policy measures that can reduce the negative impact of car ownership on the public transport use.

This paper has some limitations. In the regression analysis model, we do not consider other relevant variables, which have been commonly found to influence the demand for transport. These may include travel cost of the different modes, the number of the alternatives, location attributes and income of the households. Therefore, the future task is to incorporate these variables in modeling travel demand.

REFERENCES

Domencich, T.A., McFadden, D. (1975) Urban travel demand: a behavioral analysis. A Charles River Associates research study. North-Holland publishing company, New York

Meyer, D.M., Miller, J.E. (1984) Urban transportation planning: A decision-oriented approach. McGraw-Hill series in transportation, New York

Baker, J., Basu, R., Cropper, M., Lall, S., Takeuchi, A. (2005) Urban Poverty and Transport: The Case of Mumbai, World Bank policy research working paper 3693

Kanafani, A. (1983) Transport demand analysis. McGraw-Hill series in transportation, New York.

Ito, K., Nakamura, K., Kato, H, Hayashi, Y. (2013) Influence of urban railway development timing on the long-term car ownership in Asian Developing megacities, *Journal of the Eastern Asian Society for Transportation Studies*, 10, 2013.

Iles, R. (2005) Public transportation in developing countries. Elsevier, Amsterdam

Dargay, J., Giuliano, G. (2006) Car ownership, travel and land use: a comparison of the US and Great Britain. *Transport Research Part A*, 40 (2006), 106-124.

Vasconcellos, E.A. (1997) The Demand for cars in Developing Countries. *Transport Research Part A*, 31 (1997) 245-258

Kutzbatch, M. (2009) Motorization in developing countries: causes, consequences, and effectiveness of policy options. *Journal of Urban Economics*, 65 (2006) 154-166.

Dargay, J., Gateley, D. (1999) Income effect on car and vehicle ownership worldwide: 1960-2015. *Transport Research Part A*, 33 (1999) 101-138.

Barter, P. (2000) Urban transport in Asia: Problems and prospects for high-density cities, Asian-pacific development monitor

Ayyub, B.M., McCuen, R.H. (1997) Probability, Statistics, & Reliability for Engineers CRC Press, New York

Howe, J., Bryceson, D. (2000), Poverty and urban transport in East Africa: review of research and Dutch donor experience, World Bank report

JICA (2014) Comprehensive urban transportation master plan for the Greater Maputo, final report, vol. 1 & 2, master plan report