WCTR 2013 RIO

SELECTED PROCEEDINGS

Analysis of the evolution of travelers' mode captivity using logit modelling; with application on Greater Cairo

ALI SOLIMAN HUZAYYIN, TRANSPORT AND TRAFFIC ENGINEERING AND PLANNING FACULTY OF ENGINEERING, CAIRO UNIVERSITY, EGYPT

AMANI AHMED YOUSSEF, THE TRANSPORTATION PROGRAMME, DRTPC, CAIRO UNIVERSITY, EGYPT

This is an abridged version of the paper presented at the conference. The full version is being submitted elsewhere. Details on the full paper can be obtained from the author.

ISBN: 978-85-285-0232-9

13th World Conference on Transport Research

www.wctr2013rio.com

15-18 JULY 2013

Rio de Janeiro, Brazil

unicast

Analysis of the evolution of travelers' mode captivity using logit modelling; with application on Greater Cairo

Ali Soliman Huzayyin [1], Amani Ahmed Youssef [2]

[1] Professor, Transport and Traffic Engineering and Planning
Faculty of Engineering, Cairo University, Egypt

[2] Transport Planning and Engineering Expert,
The Transportation Programme, DRTPC, Cairo University, Egypt

Email for correspondence: <ali_huzayyin@yahoo.com>

WCTR-13, Submission for review for track:
H-3 (SIG-7): Urban Transport Planning in Developing Countries

Abstract:
Many of the travelers in urban areas of developing countries are captives to transport modes; with limited freedom to choose the desired mode of travel, particularly in the essential work and education trips. This phenomenon of mode choice behavior and how it can change as the time grows and society needs and urban travel features change, requires more attention. The objective of the paper is to investigate the evolution of mode captivity over time; with application on Greater Cairo (GC). Data of Revealed Preference Surveys (RPS) carried out in 2000 and 2009 are utilized. The paper starts, with discussing mode captivity and freedom of mode choice in previous research. Mode choice logit model is calibrated for the data of 2009 and compared with similar on the data files of 2000 and co-authored by the first author of the present paper. Using the data files of the above mentioned surveys, mode captive travelers are identified and compared for the two years. Accordingly, the sensitivity of mode choice probabilities for captive travelers to changes in transport system variables, mainly travel time and cost, are analyzed. This allowed reaching conclusions on the evolution of mode choice probabilities and the sensitivities of mode captive travelers to the considered transport system variables in GC over the decade 2000/2009. The paper ends with discussion of main conclusions, policy related implications of mode captivity evolution and suggestions for further work.

Keywords:
Mode captivity evolution; Logit modelling analysis; mode choice elasticity; GC mode choice

Analysis of the evolution of travelers' mode captivity using logit modelling; with application on Greater Cairo

Ali Soliman Huzayyin [1], Amani Ahmed Youssef [2]

[1] Professor, Transport and Traffic Engineering and Planning
Faculty of Engineering, Cairo University, Egypt

[2] Transport Planning and Engineering Expert,
The Transportation Programme, DRTPC, Cairo University, Egypt

1 Introduction

Many travelers in developing countries' urban areas, as well as in some cities of the developed world, are captives to certain transport modes with limited freedom to choose the desired mode of travel. This mode choice behavior phenomenon and how it changes over time as the society needs and urban travel features change requires more understanding. Related policy implications on decision making regarding improvement of transport facilities, transit fare values, subsidies, etc., are of particular importance. The objective is to investigate mode captivity evolution over time; with application on Greater Cairo (GC). Data of revealed preference surveys (RPS) carried out in GC in 2000 and 2009. In the current research mode choice multinomial logit model is calibrated for the RPS data of 2009. This model is used together with a pre-calibrated one for 2000 (Huzayyin and Amer, 2007) to enable examining mode choice, i.e., the sensitivity, elasticity and cross-elasticity, of mode choice probabilities of captive travelers to changes in transport system variables, travel time and cost, over the considered decade 2000/09. The conclusions are hoped to yield better understanding of the evolution of mode choice behavior in GC and to, therefore, offer guidance regarding related transport policies implications in the city.

Currently, the main formal transit modes in GC include bus and minibus, run mainly by Cairo Transport Authority (CTA) and 22 private operators, and three MRT metro lines run by a Ministry of Transport company. The informal modes are the 11 seats shared taxi microbuses and cooperatives' minibuses, both play major role in daily travel. Based on the most recent household survey (JICA, 2002), the population of GC region in 2001 is about 14.00 million, with average household size 4.27 persons and car ownership is 64 cars/1000. Daily trips are nearly 21 million; 32% of which on foot. Among the 14.40 million motorized trips; 68% are made on transit modes (25% shared taxi, 21% bus and minibus, 14% metro and 8% ordinary taxi) and 32% are on private modes (21% car, 8% bus and 3% others). A more recent study (SYSTRA/DRTPC et al, 2009) gives an estimate of GC population in 2009 as some 18 million and the number of daily motorized trips as more than 16.5 million, of which 69% are by public transport and 31% by private transport. It is interesting to observe that the split of motorized trips ratio between transit and private modes is almost the same in 2001 and 2009; even though the values are increased. Since the late 1980s, shared taxi modal share of daily trips is continuously increasing as well as metro trips at the expense of bus travel which are continuously declining. Comprehensive analysis of the evolution of GC urban development, transport supply and demand and energy/environment since 1971, refer to (Huzayyin and Salem, 2013).

It should be noted that the situation in Egypt after January 2011 revolution and the new era towards democracy, freedom and social justice; would have impact on the daily life of GC residents and the national economy. This calls for undertaking future transport studies and surveys including demand surveys, RPS, etc., which have not been possible at the date of preparing this paper while the country is in a transition period.

2. Mode captivity and freedom of mode choice in previous research

Captive travelers are defined and explained in a variety of ways. According, to (Christoffel and Anand, 2009), which referred to (Ben Akiva and Lerman, 1985), captivity is associated with the situation when the choice set of an individual is limited to merely one alternative or to small number of alternatives at most. References (Huzayyin and Amer, 2007) and (Gokmen et al, 1999) classify captive travelers in a binary way such as “transit captives” versus “non-transit captives” or “captives out of obligation” versus “captives out of choice" as discussed below. Captivity could also be seen as human behavior classified into degrees and depends on many factors. Reference (Viegas et al, 2008) established a hierarchy of needs (based on that of Maslow, 1943) to understand how an individual selects a transport mode. This hierarchy ranks “safety” and “security” first in the traveller needs, then comes “time” followed by “social acceptance”. “Cost” comes forth and finally are “comfort” and “convenience”. Of course it can be argued that such ranking can widely differ from a traveler to another based on many factors, including, but not limited to, gender, age, income, occupation, trip purpose and the relative level of service offered by the available transport modes on the choice set of the traveler for a particular trip.

The issue of mode captivity is addressed from another point of view that considers the time frame within which the captivity is defined, (Gokmen et al, 1999). This implies investigating captivity via time series measurement to discriminate between “situational captivity”, i.e., where the bus is only available and “attitudinal captivity” that covers effects of many elements, e.g., personal habits and loyalty as well as resistance to change. The same reference indicates that analyzing captivity in such way can yield different degrees of captivity.

Captive travelers in South Africa are classified into six types (NDT, SA, 1998). Striders; those who choose non-motorized with no problem with travel time and enjoying the low coast, stranded; walk captives with no affordable transit available, survivals; captives to the cheapest transit, sensitives; transit captives who cannot afford but transit modes, selectives; transit choosers who afford a car and willing to use transit if it meets speed/convenience needs and stubborns; car captives who only use the private car.

Reference (Jacques et al, 2012) relied on cluster analysis using several key variables to classify travellers. One of the important variables is "practicality"; defined as the ratio between “travel time” of the alternative trip option and “travel time” by the mode actually used for the trip. Another important variable is "trip satisfaction"; which is used to show the level of enjoyment an individual derives from the current trip; using a scale ranging from the very satisfied to the very much unsatisfied. The analysis revealed the following four distinct clusters rather than the traditional segments of "choice" and "captive" users; true captivity; individuals having low trip practicality and low level of preference for their trip, dedication; individuals having low level of practicality, but who are satisfied with their trip, utilitarianism; individuals having low level of preference, but high level of practicality and convenience; individuals having both “high level of preference” and “practicality”.

Similar approach is adopted in another research work, (Diana and Mokhtarian, 2009), the resulting clusters are; "heavily car oriented", "rather car oriented", “more transit oriented" and "light travelers". Another work, (Jillian, 2005) classifies travelers into four car-owning and two non-car-owning groups; malcontented motorists: perceive high number of constraints to transit use , unhappy with car travel and believing a moral responsibility to alter, complacent car addicts: admit that the use of alternative modes is possible, but do not feel any moral imperative to alter, aspiring environmentalists: appreciate the practical advantages of car travel and are reluctant to give up ownership, die hard drivers: fond of cars and car travel, believe in the right to drive cheaply and freely and have negative feelings towards all other modes, car-less crusaders: have sacrificed car ownership for environmental reasons and have positive evaluations of all other modes; and finally, the reluctant riders: prefer to travel by car and either aspire to owning a car in the future or accept lifts by car when possible. It is believed, however, that the above classification is much geared to rich communities and may not be always valid for cities in developing countries.

Another recent research oriented to developing countries (Huzayyin and Amer, 2007) analyzed thoroughly the reasons of mode captivity in GC. It considered two types of captive travelers. The first type is the "captives by obligation" such as those who are obliged to go to work/school on foot as they cannot afford motorized modes, public transport users who cannot afford running a private car or travelling by taxi. The second type is the "captives by choice", such as travelers who cannot choose but the private car regardless of any comparative advantages of possible alternatives or are obliged to use the car because the best high quality public transport mode, the metro, is far from the locations of the origin/destination of the trip. This type also includes those who travel by metro because of its access to their desired trip locations and the high level of service it offers. Detailed discussion on the above mentioned types of captive travelers is given in the cited reference.

It is clear from the above review that mode captivity is understood and, hence, explained and defined in a variety of ways. It is also believed that as time grows, classification of mode captivity of urban travelers into different types differs from urban area to another; and even within the same urban area. Such difference is deeply tied with the advance of societies and the prevailing life styles of citizens, the sharp differences between the industrialized world and the developing countries’ urban areas. It is also clear that in order to cater for the varying behavior patterns of the travelers in urban areas, it is essential for researchers to define different groups of traveler and to plan for their needs of transport modes; and systems. This will then have corresponding implications on policy decisions, and eventually, on future transport projects in the city.

3. General Methodology and Available Information

The adopted methodology in the present work is shown in Figure 1. Four main inputs are utilized;

- RPS data of 2000 (JICA, 2002).

- Logit model calibrated using the RPS data for 2000 with a sample of just under 800 respondents (Huzayyin and Amer, 2007).
- Elasticity and cross elasticity of captive travelers for 2000 RPS data, (Huzayyin and Amer, 2007).
- RPS data of 2009 (SYTRA/DRTPC et al, 2009).

The 2009 multinomial logit model is calibrated, for the relevant RPS data set with sample size of 500 respondents. In order to carry out comparisons on the same grounds, the same transport modes that were used in the calibration of 2000 logit model are used when calibrating the 2009 logit model. These are formal bus (and minibus), informal shared taxi (and coops minibus), metro and private car (including ordinary metered taxis). The same system attributes are also used in the calibrating the two logit models. Those are travel time and travel cost. Travel time segments as in vehicle time, out of vehicle times, access and egress times and transfer times for transit are considered and for transport cost prevailing transit fare values and car operating costs are taken into account. As for the socio-economic attributes the same variables are tried as input during logit model calibration for 2000 and 2009. These include traveler age, gender, occupation and income. It is important to note that the 2000 and 2009 RPSs were carried out by the same research team from the Transportation Programme, DRTPC, Cairo University as per the two references (JICA, 2002) and (SYSTRA/DRTPC et al 2009), respectively.

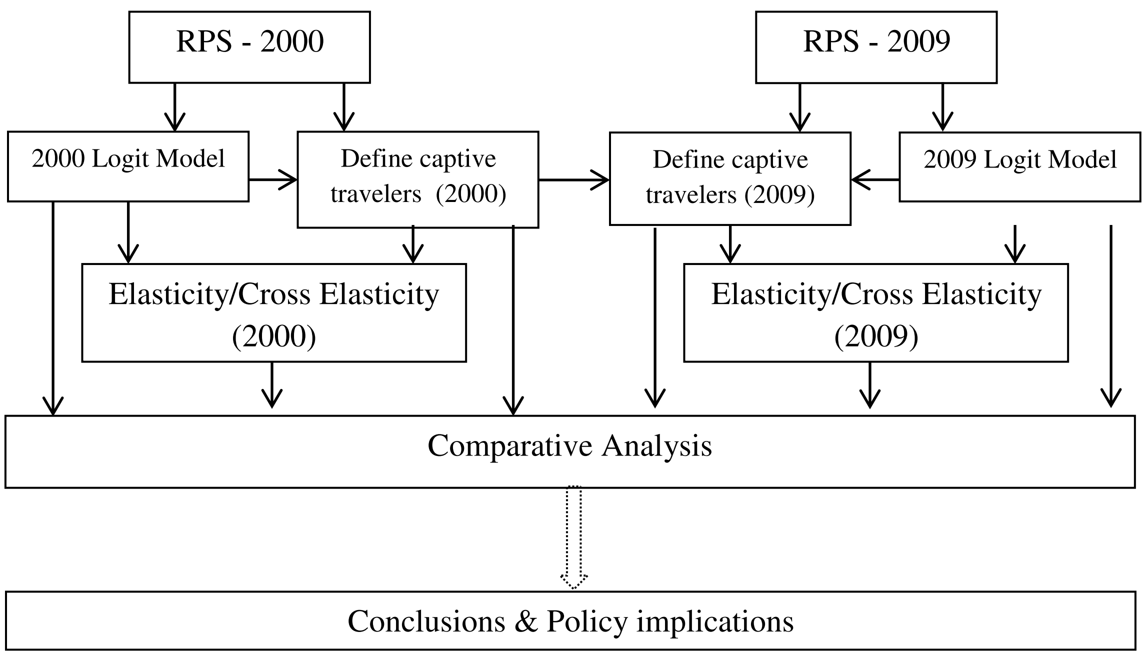

Figure 1: Applied methodology flow chart

Then, "captive travelers" segmentation are identified for the two RPS data sets of 2000 and 2009 on the assumption that a traveler is said to be captive to a certain travel mode if his/her "choice probability" of that mode is greater than a threshold of 0.50. The later threshold probability ratio is an arbitrary one which reflects a "degree of captivity" for distinguishing captives from choosers. For instance, a probability threshold of 0.75 was used in reference (Gokman, et al, 1999) and any other ratio can be adopted as well. However, in the present research the decision to choose a minimum value of this arbitrary threshold of 0.50 is taken, in order be consistent with the ratio that was determined in the previous work of 2000 (Huzayyin and Amer, 2007) based on statistical analysis of the distribution of choice probabilities from the modal sample of RPS data set. This consistency of using the same threshold of defining mode captive travelers for 2000 and 2009 data sets, allowed carrying pout comparisons of the results of the present work at the same grounds.

In order to assess the evolution of mode captivity between 2000 and 2009, sensitivity of mode choice probabilities to changes in transport system attributes are compared as estimated using the two, respective, calibrated logit models. Sensitivity is reflected by mode choice "direct elasticity" and "cross elasticity" of the identified captive travelers to changes in travel time and cost. Accordingly, conclusions and policy implications of transport system attributes' changes are discussed.

4. Greater Cairo Mode Choice Logit Models

4.1 Logit Model of 2000

Table 1 gives the utility function calibrated for 2000 RPS data set as per (Huzayyin and Amer, 2007), where it is indicated that the sample was a choice based one and the number of interviewed persons for each mode coincided well with modal shares in GC in that year. The same reference also indicates that the utility function was reached after many trials of different specifications using different socio-economic variables and system attributes. It is clear from Table 1 that in the given utility function all the variables are logical and have the expected signs. The t-statistics should not be taken as a matter of concern as long as the variables are logical in explaining mode choice and appear with the right sign; based on the explanation given in reference (Ben Akiva and Lerman, 1985). In addition, the results of the prediction tests; outliers and market segment prediction, indicate that the utility function of the logit model is satisfactory. The outlier analysis test showed that only 6 out of 799 observations have a predicted probability of the chosen mode < 0.05. The market segment test showed the ability of the model to predict the share of market segments, gender (male/female) and occupation (worker/student/other) successfully; except in very limited cases (Huzayyin and Amer, 2007). The latter reference gives analysis and detailed discussion of the model given in Table 1.

4.2 Logit Model of 2009

Table 2 gives the sample size distribution of the 2009 RPS data by mode and the global modal shares of GC for 2001 and 2009, where it is clear that the choice based sample represents well the global modal shares in GC in both years. As usual in logit model calibration, many specifications of the utility function were performed using different socio-economic variables and system attributes of travel time and cost components as per the 2009 RPS data set. The final version of the utility function is given in Table 3, where it can be seen that the variables which appeared in the function are as defined below.

Table 1: Utility function of the calibrated mode choice logit model for Greater Cairo using 2000 RPS data, source: (Huzayyin and Amer, 2007).

Variable	Applied to mode	Coefficient estimate	t-statistic	Standard error
Bus constant	Bus	-0.84798	-1.41790	0.59805
Shared taxi constant	Shared taxi	-0.91625	-1.59399	0.57482
Car constant	Car	1.69305	2.15024	0.78738
Male (dummy)	Car	0.90522	1.28630	0.70374
Age 20 to 40 (dummy)	Shared taxi	0.23682	1.15470	0.20510
Student (dummy)	Metro	0.09231	0.18660	0.49470
Worker (dummy)	Bus	0.51250	1.06453	0.48144
Worker (dummy)	Shared taxi	0.30433	0.63412	0.47992
Total travel time	All	-0.00111	-0.35924	0.00308
Total travel cost	All	-0.00030	-0.45626	0.00067
Access + egress Time	Bus	-0.00404	-0.31799	0.01269
Access + egress Time	Shared taxi	-0.02175	-1.48344	0.01466
Access + egress Time	Metro	-0.01441	-0.94835	0.01519
Number of transfers	All	-0.34211	-2.63352	0.12991
Waiting time	Bus	-0.00471	-0.63624	0.00740

Variables = 15, observations = 799, $L^0 = -571.26$, $L^{*} = -426.807$, $-2\,[L^{*} - L^0] = 288.904$, $\rho^2 = 0\ 252866$ & adjusted $\rho^2 = 0.226608$

Table 2: 2009 RPS sample size distribution by mode (%) and 2009 Greater Cairo modal share (%)

Mode	Sample size		Greater Cairo modal share (%), 2009*
	No.	%	
Car	164	32	31
Bus	105	21	24
Shared taxi	165	33	34
Metro	65	13	10
Light rail tram+	5	1	1

* Based on (SYSTRA/DRTPC, et al, 2009)
\+ Excluded from the present paper for its very minor role

- Generic system variables:
  Total travel time = Continuous variable indicating total travel time in (min).
  Total travel cost = Continuous variable indicating total travel cost in (LE).
- Alternative specific system variables:
  No. of transfers = Continuous variable indicating number of transfer times applied to "bus"
  Certainty dummy = Dummy variable applied to “metro” indicating the level of certainty a user associates with the availability of the travel mode (vehicle) at that time. Two levels are utilized; certain = 1.0 (meaning user is reasonable certain the vehicle will arrive when expected) and uncertain = 0.0 (user is not sure of when to expect vehicle to arrive).
- Alternative specific socio-economic variables:
  Low income = Dummy categorical variable applied to "shared taxi"; = 1 for user income < 500 L.E per month and = 0 otherwise).
  Worker = Dummy categorical variable applied to "metro"; = 1 for workers and = 0 otherwise).
- Constants:
  Constant specific to Car
  Constant specific to Bus

For the selected utility function given in Table 3, it is clear that all the variables are logical in explaining mode choice probabilities and all appear in the function with the expected ‘right’ signs, irrespective of the values of t-statistics for some variables which should is not a matter of concern, as mentioned earlier, as long as the variable and the associated sign of its coefficient in the utility function are logical. As for the prediction tests the model correctly predicted 75% of the choices actually made by the sample. In addition, the results of the different prediction tests; outliers and market segment prediction tests, indicated that the model is very satisfactory. The outlier analysis test showed that only 22 out of 492 observations have a predicted probability of the chosen mode < 0.01. Whereas, the market segment test showed the ability of the model to predict the share of market segments, gender (male/female) and occupation (worker/student) successfully; except in very few cases.

5. Evolution of Mode Captivity 2000/2009

5.1 Logit models 2000 compared to 2009

Comparison between the utility functions of the calibrated logit models of 2000 and 2009 is given in the current section. Before doing so, it should be noted that by this comparisons the intention is not to draw one to one conclusions. However, the objective is to give a general insight on the variables that appeared in each utility function that was found to be the best at the end of the calibration process using two compatible RPS data sets for the same urban area in two points of time.

Table 3: Utility Function of the calibrated logit model for Greater Cairo using 2009 RPS data set

Variable	Applied to mode	Coeff. Estimate	T test	Standard error
Total travel time	All	-0.003574	-1.046096	0.003417
Total Travel Cost	All	-0.046056	-1.754034	0.026257
Car Constant	Car	2.988255	7.612115	0.392566
Bus Constant	Bus	0.269471	1.418256	0.190002
Number of transfers	Bus	-0.984075	-3.417318	0.287967
Low income (dummy)	Shared Taxi	1.313208	4.004087	0.327967
Worker (Dummy)	Metro	-1.526146	-2.918891	0.522851
Certainty	Metro	3.962884	7.337578	0.540081

Variables = 8, observations = 492, L^0 = -463.69, L^* = -275.933, $-2\ [L^* - L^0]$ = 375.509, ρ^2 = 0 404916 & adjusted ρ^2 = 0.387663

As can be seen from Tables 1 and 3, it is noteworthy that the utility function of 2009 includes total travel time and total travel cost for all modes. As given in Table 1, there are segmented travel time variables (access + egress time) by mode (bus, shared taxi and metro) and waiting time for bus. However, when those segmented variables of travel time introduced into the utility function trails for 2009 RPS data, the results were not satisfactory. Also the utility function includes number of transfers for both models. The certainty dummy variable that was used in 2009 model proves to be important for the metro utility function. This is logical as one of the main advantages of the metro is punctuality.

5.2 Captive travelers in 2000 and 2009 samples

As mentioned earlier, "captive travelers" are identified for the two RPS data sets of 2000 and 2009 based on the assumption that a traveler is said to be captive to a certain travel mode if his/her ‘choice probability’ of that mode is greater than a threshold of 0.50. It is to be noted that although 0.5 may be considered low threshold to define mode captives, however, it was taken in order to allow comparisons of 2009 logit model variables with those of 2001 as the latter used this threshold. This was adapted in (Huzayyin and Amer, 2007) based on cumulative frequency distributions of choice probabilities of the chosen modes. Conducting future research on the threshold of mode choice captivity in cities of the developing countries is strongly recommended. Accordingly, Table 4 gives the distribution of mode captive travelers among the 2000 and 2009 RPS samples.

Table 4: Distribution of mode captive travelers among the RPS data sets for 2000* and 2009

Chosen Mode	Travelers in the sample		% Travelers in the sample		Captive travelers in the sample		% Captive Travelers	
	2000	2009	2000	2009	2000	2009	2000	2009
Car	231	164	29	33	217	156	93.9	95
Bus	237	102	30	21	171	50	72.2	49
ST	185	161	23	33	121	109	65.4	68
Metro	146	65	18	13	89	65	61.0	100
Total	799	492	100	100	598	380	74.8	77

* (Huzayyin and Amer, 2007)

As given in Table 4, the % of captive travelers almost remains unchanged for both data sets and 2000 and 2009 for car and shared taxis. However, bus captives decreased by 30 % in 2009 as compared to 2000. This could be attributed to the expansion of the shared taxi; the vehicles, the routes and the services and the deterioration of the bus service. In 2000 bus trips reached about 3 million trips while in 2009 this number was reduced to 2.5 million and it is recorded to be 2.2 million for 2012. It is important to note that in 2009, 100% of metro users in the sample are found to be captives to metro compared to about 75 % for 2000. This is believed to reflect three indications: (a) the lowered travel speed on the street network, (b) the difficulty to find parking places at certain destinations and (c) the sustained high level of service of the metro.

5.3 <u>Evolution of Mode Captivity 2000/2009</u>

After identification of captive travelers of different travel modes in the 2009 RPS sample, "elasticity" and "cross elasticity" of those travelers with respect to changes in travel time and travel cost, the system attributes that appear in the utility function, are estimated. These are compared with those calculated for 2000 RPS sample as given in Tables 5 and 6.

It is clear that mode captivity looks similar over the considered ten years in GC as the absolute value of elasticity is always very low. However, comparing the relative increase, or decrease, of direct elasticity and cross elasticity by mode for 2000 and to 2009 can give insight on mode choice captivity evolution, as discussed below.

As far as the sensitivity of mode choice for captive travelers to travel time is concerned, it is clear that for all modes, the direct elasticity of captive travelers is less in 2009 than in 2000. This means that over the decade 2000/2009 travelers have become less willing to change the travel mode of which they are captive, due to increase in travel time. Also, for all transit users, an incremental increase in travel time would lead to a decrease in the use of alternatives modes in 2009 compared to 2000. This means that transit users have become unwilling to shift to other modes even if travel time saving is offered by those alternative transit modes. This looks logical

Table 5: Mode choice elasticity for mode captive travelers by travel time and cost for 2000, (Huzayyin and Amer, 2007)

System Attribute	Travel Mode	Elasticity of captive travelers			
		Bus	Shared taxi	Metro	Car
Travel time	Bus	-.0265	.0271	.0060	.0003
	Shared taxi	.0228	-.0264	.0162	.0012
	Metro	.0021	.0041	-.0181	.0006
	Car	.0000	.0000	.0000	-.0016
Total travel	Bus	-.0087	.0084	.0012	.0001
	Shared taxi	.0116	-.0148	.0103	.0007
	Metro	.0014	.0019	-.0105	.0007
	Car	.0000	.0000	.0000	-.0102

Table 6: Mode choice elasticity for mode captive travelers by travel time and cost for 2009

System attribute	Travel mode	Elasticity of captive travelers			
		Bus	Shared taxi	Metro	Car
Travel time	Bus	-0.0019	.00150	.00150	.00009
	Shared taxi	.00014	-.00020	.00020	.00083
	Metro	.00011	.00010	-.00010	.00001
	Car	.00000	.00000	.00000	-.00002
Travel cost	Bus	-.00150	.02600	.00150	.00300
	Shared taxi	.000300	-.01500	.00020	.00360
	Metro	.000000	.00190	-.00010	.00030
	Car	.000000	.00000	.00000	-.00120

and can be attributed to the fact that all road based transit modes practice the same traffic congestion and reduced level of service which have increased between 2000 and 2009. Furthermore, the metro though offers a very high level of service, yet it is geographically not accessible to origin/destinations far from its routes. In addition, insufficient route integration and the lack of fare integration with the metro lines, make some of those destinations more inaccessible.

It is also interesting to observe that for an additional increment of increase in travel time by car there would be a decrease in the probable use of all transit modes for 2009 compared to 2000. This is a logical result. The main mode of transit that offers an acceptable alternative to car users is the metro. However, as traffic congestion has increased over the considered decade as well as the increased parking problems around metro stations; it has become less advantageous for many car users to park and ride at metro stations. They would go directly to their destination by car as the time of the two mode (car +metro) journey would be more than a direct link by the car. It can be argued that in such trips the car user can experience parking problems at the final destination of the trip. This issue is very much related to each individual case and cannot, hence, be generalized, as still the metro is the choice for some car owners for certain trips.

Considering sensitivity of mode choice for captive travelers with respect to travel cost, a number of interesting comments appear from Tables 5 and 6. For instance, for 2009 if bus fares increase, the shift of bus captive travelers to other 'affordable' alternative public transport modes is less than the corresponding shift that they would have done in 2000. This leads to the conclusion that over the considered 10 years, bus users' captivity to the bus has been becoming more profound by time. This can be directly attributed to increased cost of travel on shred taxi compared to the bus, on which fare values have not been unchanged for the common services. As far as the sensitivity of mode choice for captive travelers to travel time is concerned, it is clear that for all modes, the direct elasticity of captive travelers is less in 2009 than in 2000. Although over the decade 2000/09 fares on shred taxi also did not change, yet in absence of proper enforcement, drivers cut the routes into sectors so the passengers had to disembark and board another vehicle; thus paying twice the advertised fare in order to complete the original trip length.

Furthermore, it appears that for shared taxi captive users a 1% increase in travel cost is associated with an increase in bus use by 0.0084% for 2000 versus 0.0260 % in 2009. At the same time; a 1% increase in shared taxi travel cost would increase bus usage by 0.026% in 2009 and decrease the shared taxi usage by 0.015% in 2000.This confirms the above conclusion; because if the already artificially (illegal) high fares on shred taxi increase further, its captive users would think of a shift to the bus with stabilized fares. This is also the case if fare values on the metro increase by 1 % the impact on bus ridership would be much higher in 2009 than that on shared taxi ridership and also for the relevant two cases for 2000. Similarly, captives of the metro would still shift to bus in case of change metro travel cost.

Some of the private car (and ordinary taxi) captive users seem to would accept to shift to bus and shared taxi in case of unit increase in travel cost. This is observed for 2000 and 2009 alike. This can be a logically acceptable result for low income car owners and some of the taxi users who sacrifice its high cost for sake of comfort. Examples of the latter users are female and the elderly passengers, or those carrying heavy goods. However, this cannot be explained for the middle and high income car users who over the years have not been expected to shift to transit. The only possibility is a shift from car to metro. It is interesting to note that the above conclusion seams more profound in 2009 than in 2000 as it appears from the corresponding elasticity in Tables 5 and 6. This is a direct result of the deteriorated level of service of road based public transport over the considered decade. For instance bus passengers have decreased from about 3 million in 2000 to nearly 2.3 million in 2009.

6. Conclusions and policy implications

Bearing in mind the results of the present research and the discussion given in Section 5, the present section gives the main conclusions and relevant policy implications. First of all, it is necessary to use updated logit models as the variables on the utility function, and hence the function itself, change over time. For instance in the case of GC, there are major differences between the variables appearing in the utility function of the logit model calibrated for RPS data of 2000 and those of the utility function calibrated using the 2009 RPS data set. Otherwise, the use of the 2000 model and not the updated model for 2009 model for mode choice prediction, had the latter not have been available, would have led to inaccurate estimation of modal ridership in GC. Consequently, this can mislead transport policy decisions in the city. Updated analysis of user perception of the transport system variables, particularly public transport, is therefore, quite important for policy makers and can seriously direct future investment and sustainable functioning of the city.

Secondly, it is clear that mode captivity of GC citizens is persisting over the decade 2000/09 and, hence, it is believed that this phenomenon of travel behavior is most likely to continue for the coming years; unless serious policies are in place with respect to certain travel modes and networks. In addition, it is concluded that different groups of traveler need to be served in different ways according to their travel mode of preference, or in other words the mode they are captive to. This can influence policy decisions as well. For instance, policies concerning investing in improving bus performance and levels of service are very important in GC because they can easily influence modal shift from shared taxi. Closely related is rethinking the size of the bus, as smaller size vehicles can provide easier access to certain locations to compete with the shared taxi. However, if this is to be applied, then energy and environment considerations should not be ignored with respect to the smaller size buses, and, hence, tradeoff should be sought.

Another conclusion is that the metro may relatively free some of the car captives from such captivity. This is attributed to the high level of service the metro provides with its 33 km/hr average commercial speed and 3.5 min headway with clean stations and strictly non-smoking vehicles and stations, etc. However, many car users are still having origin and/or destinations of their trips geographically away from metro stations of the three lines.

In connection with the above issues, is adopting policy to introduce new high level of service bus lines that can easily help to free car captives to shift to the bus as the metro is providing to some car captives. It is obvious that under the prevailing deteriorated level of service of the common bus lines; middle and high income car users are not expected to shift as has been the case over the decade 2000/09. It is interesting to note that a pioneer pilot project is underway (Transportation Programme, DRTPC, 2009 / till now) to design and provision of privately operated high level of service bus lines in GC for the above purpose. Two concepts of those lines are underway: (a) three lines to connect new cities in the west of GC with the metro lines, and (b) four lines to serve high four income districts in GC with the metro. The objective of the former lines is to reduce traffic congestion of the corridors leading to GC and that of the latter is, in addition to that objective, to reduce congestion around the connecting metro stations due to the seriously insufficient park & ride facilities at those stations. In both cases the new lines will apply high fares in order to keep the attractive level of service and to sustain modal shift from car. Besides, the lines are planned to allow the operators to generate out of the ‘fare box’ financing through advertising and exploitation of stations surrounding areas. The general goal of the pilots is a full scale replication. It is clear that if such car/bus modal shift, can be gradually achieved, many energy and environmental positive gains can be reached. However, for the above pilots to succeed awareness campaign is to be launched to inform car users of the new lines, assuring them of the level of service, to exert control on the operators to sustain that level of service and to draw the attention of car users to rationalize on gasoline spending. In deed the new policy of the government which is implemented in November 2012 to set the cost of the high octane gasoline to the international market price is a positive step in that direction.

In addition, it is important to note that based on the analysis in section 5, the illegal practice of shred taxi drivers in increasing fares by segmentation of the licensed routes in order to overcome the prevailing unchanged fare values puts heavy burden on the already crowded buses. The policy makers have to reach a practical policy of applying marginal increase of the legal fares on the licensed full routes and very tight control on the drivers.

Finally, it is suggested that further research is required in four directions. First, is to elaborate the definition and identification of mode captive travelers from RPS data and to try to achieve practice verification from wider surveys. This also envisages the need to investigate the issue of threshold of identifying mode captive travellers in cities of developing countries as mentioned earlier. Second, is to study the evolution of mode captivity of travelers in other urban areas by applying similar methodology to that applied in the present work. The objective is to compare notes and to investigate extracting possible generic lessons. Third, studying transferability of mode choice models over time is another interesting topic for future research. Fourth, is to seek more knowledge on logit modelling analysis for studying the evolution of mode captivity and its related conclusions and implications on policies of urban transport provision, improvement and/or expansion.

7. References

Beimborn, Edward A., et al, 2003, Accessibility, connectivity, and capacity impacts on transit choice, Transportation Research Record: Journal of the Transportation Research Board, No. 1835, pp. 1–9

Ben Akiva, M. and Lerman, S.R., 1985. "Discrete Choice Analysis: Theory and Application to Travel Demand", MIT Press, Cambridge, Massachusetts

Christoffel Venter, Anand Venkatesh, 2009. "Modeling Captivity and the Demand for Motorised Transport in Rural Areas of South Africa", 12th International Conference on Travel Behaviour Research, Jaipur, India

Diana, M. and Mokhtarian, P.L., 2009. "Grouping travelers on the basis of their different car and transit levels of use", Transportation, Vol. 36 (4), pp. 455-467

Gokmen, E., Peter R. Stopher, and Hasan, M. Al-Ahmadi, 1999. "Captivity revisited", Reviewed, Urban Transportation Division

Huzayyin, A. and Amer, A., 2007. "Mode captivity and mode choice in urban travel using logit model analysis, with application on Greater Cairo", World Conference on Transport Research, WCTR-11, Berkeley, USA

Huzayyin, A. and Hindawi, S., 2013. "Analysis of thirty years evolution of urban growth, transport demand and supply, energy consumption, greenhouse and pollutants emissions", Research on Transport Economics, RETREC Special Issue, Vol. 40, Issue 1, pp.104–115 Elsevier.

Jacques, C., Manaugh, K., and El-Geneidy, A., (accepted) 2012. "Rescuing the captive [mode] user: An alternative approach to transport market segmentation", TRAM Seminar, McGill University http://tram.mcgill.ca/Teaching/seminar/presentations/Rescuing_Captive_User.pdf
JICA, 2002. "Cairo Regional Area Transportation Study (CREATS)", JICA for Ministry of Transport, Cairo, Egypt, Phase I Final Report

Jillian A., 2004. "Complacent car addicts' or 'aspiring environmentalists'; identifying travel behavior segments using attitude theory", http://www.journals.elsevier.com/transport-policy/most-downloaded-articles/

José Manuel Viegas, João de Abreu e Silva, Rafaela, A. C., 2008."Innovationin transport modes and services in urban areas and their potential to fight congestion", Instituto Superior Técnico, Portugal

NDT, SA, 1998. "Moving South Africa: A Transport Strategy for 2020", National Department of Transport, South Africa, Final Report retrieved November 15, 2006, http://www.transport.gov.za/projects/msa/msa.html

SYSTRA/DRTPC, et el, 2009. "Greater Cairo Public Transport Study Update and Line 3 Phase 3 Design Study", for the Ministry of Transport

Transportation Programme, DRTPC, Cairo University, 2009. "Sustainable Transport Project for Egypt", GEF/UNDP, for the Ministry of Environmental Affairs and GEF/UNDP, Cairo, Egypt