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Modelling the Impact of Residential Location Preference on Travel Mode Choice in Benin Metropolitan Region

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ABSTRACT

A plethora of existing studies have dedicated much attention in exploring the influence of the physical neighbourhood covariates on travel mode choice without considering the impact that household preferences for residential location can exert on travel mode decision making process. Hence, this study was designed to examine residential location preference of commuters and its relationship with travel mode choice in Benin Metropolitan Region (BMR). A binomial logit model was computed to test the significance of the formulated hypothesis and estimate the influence of residential location preference on travel mode choice using 1836 households selected from the study area. The results generally showed that in BMR, the desire to choose between motorized mode of travel and non-motorized mode is significantly influenced by residential location preference. Specifically, the findings suggest that accessibility factors such as neighbourhoods found along high priority roads and those with good road network encourage dependence on motorized travel mode. Contrarily, those who prefer to reside close to their place of work may likely patronize non-motorized modes so as to cut down transport cost.

1. INTRODUCTION

The individual motives such as needs, desires, values and preferences often spur a household to make certain decisions concerning where to live (Nkeki, 2018). Arguably, the neighbourhood characteristics may play a vital role in influencing people's preference for residential location but the choice of residential neighbourhood is to a large extent a function of the decision maker's demographic and socioeconomic characteristics (Weisbrod *et al*., 1980; Nkeki and Erimona, 2018). However, the decision to walk or to drive or to patronize a public transport may be directly influenced by these preferences for residential neighbourhood. It is assumed in the literature that such decisions are made jointly, and since neighbourhood appears in the mode choice utility function, it is therefore considered as an endogenous variable (Zahabi *et al*., 2012).

The need to understand people's travel attitude has become a foremost issue in literature for over three decades (Boarnet and Sarmiento, 1998; Bhat and Guo, 2007; Vega and Reynolds-Feighan, 2009). Improving the knowledge on travel behaviour by identifying the factors that may help explain people's choice of travel mode will apparently serve as a useful tool for effective policies that seeks to reduce motorized mode of urban travel. Several policies have been brought to limelight which are designed to effectively integrate land use and transport in other to discourage heavy dependence on car-based travel. Popular among these policies are the *New Urbanism* (Congress for the New Urbanism, 2013) and the *America Smart Growth* (American Planning Association, 2002). The central objectives of these policies are to mitigate the problem of air pollution, greenhouse gas emission, cut down the daily amount of fossil fuel consumption, reduce congestion and travel time.

Bulk of existing studies have dedicated much effort and attention investigating the impact of the physical neighbourhood characteristics (such as design, density, land use diversity, accessibility, etc.) on travel mode choice and other travel-related attitudes without looking at the effect of people's preferences for a residential neighbourhood on their travel mode decision making process (Boarnet and Crane, 2001; Schwanen and Mokhtarian, 2005; Badland *et al*., 2008; Brownson *et al*., 2009; Ewing and Cervero, 2010; Ewing, *et al*., 2011). In these studies, the neighbourhood and built environment characteristics were represented with indicators or proxy covariates which are not directly connected to the respective individual choice maker or travel mode user. Though, the existing neighbourhood design on a microscale and the built environment on a macroscale provide diverse options for households to select the most suitable residential location but as noted in previous literature, it is the preferences that most often initiate the large scale changes observed in most urban landscapes (Wu, 2003; Nkeki and Erimona, 2018). Consequently, such preferences may have significant impact on travel mode choice.

These previous studies have assumed that travel mode choice is better explained by the physical neighbourhood characteristics (Boarnet and Crane, 2001; Zhang *et al*., 2012; Aditjandra, 2013; Pitombo *et al*., 2011; Cervero and Duncan, 2002; Holtzclaw *et al*., 2002; Miller, 2003). For example, Limtanakool *et al*. (2006) assumed that density, accessibility and land use diversity are the three main characteristics of neighbourhood that influence travel attitude in the USA. This was supported by Frank and Pivo, (1994), Newman and Kenworthy, (1989) and in Europe by Dargay and Hanly, (2004) and Schwanen *et al*. (2004). These scholars revealed that higher population densities are associated with smaller shares for the private car and larger proportion of travel by public mode and cycling/walking. Some previous literature evidence also revealed that compact urban density has high likelihood of reducing travel by car and encourages non-motorized mode (Crane and Chatman, 2003; Comendador *et al*., 2014).

The major objective of this study was to examine the factors for residential location preference of commuters and their relationship with travel mode choice in Benin Metropolitan Region (BMR). To achieve this, the hypothesis that travel mode choice of commuters is not significantly influenced by their preferences for residential location was formulated.

2. METHODOLOGY

2.1. Study Area

Benin Metropolitan Region (BMR) which is among the fastest growing ancient cities in Nigeria was chosen for this study. The region presents an interesting case study for this work because of its unique morphology, spatial pattern, population and socioeconomic characteristics, level of land use mixture and land use transition (Nkeki, 2016). BMR can better be described as a contiguous built-up or urbanized region consisting of heavily compacted and highly functional core axis and its suburban and outlying areas are connected together by the well-linked road network. The road network serves as a means of integration between the suburban residential area and the work location in the core axis.

The geographical location placed BMR in the southern margin of Edo State between latitudes 6° 16' to 6° 33' N and longitudes 5° 31' to 5° 45' E (Figure 1). Initially, the urbanized part of the region spread over three local government areas (LGAs), which are Oredo, Egor and Ikpoba-Okha. Overall, its territorial coverage is roughly 1,318 km^2 with 166 km in the perimeter and an average elevation of about 78 meters above sea level (Ekhaese *et al*., 2014; Nkeki, 2013). Due to its rapid growth, the metropolitan region has presently spread into two additional contiguous LGAs which are Ovia northeast and Uhunmwode.

Urban sprawl is fast developing in the region and it is believed to have been initiated by residential growth (Nkeki, 2016). Urbanization process initiated further by associated economic forces is the chief factor that has led to the observed residential development. These developments have somewhat mounted pressure on the inner city residents and led them to relocate to the suburban region since the cost of land and rent are more affordable. The residential growth as noted by Nkeki, (2016) formed linear clusters along the trunk roads which radiated from the urban core toward all directions of the edge of the city. The region has therefore been partitioned into three residential zones-the inner city or urban core, transition zone and suburban zone. However, residential activities are gradually paving way for commercial land use development in the urban core and becoming more concentrated in the suburban region. The residential location preference is made within this zonal framework in association with the travel needs of the household.

BMR generally depends on vehicular mode for urban travel, specifically, work-related travel. Unlike cities of most developed and some developing countries, the region lacks effective means of mass transit such as intracity rail or the modern speed rail system like that found in Beijing, intracity inland water transport like that found in India cities etc. The major modes of urban travel in the region are private cars, taxis, public minibuses (locally called Tuketuke), large compartment buses (known as comrade bus), medium compartment buses (such as UNIBEN shuttle bus) and recently introduced engine-based tricycle (popularly called keke). The UNIBEN shuttle buses were originally designed to provide cheap and coordinated transportation services for the staff and students of the University of Benin. These buses ply two major routes within the metropolitan region-Ugbowo-Ring Road route and Ugbowo-New Benin Market routes.

Recent government policy action took the tricycle off the major roads and restricted it to residential access roads. Also, the use of motorcycle popularly known as Okada as a means of public transport in the region was prohibited and hence this was not captured in this study. The comrade bus is a government urban mass transit initiative that ply the trunk roads connecting the central business district (CBD) (Ring Road axis) with the suburban areas of the region. Basically, the taxis and Tuketuke buses are not tailored to any custom route as they are ubiquitous across almost every route within the metropolitan region.

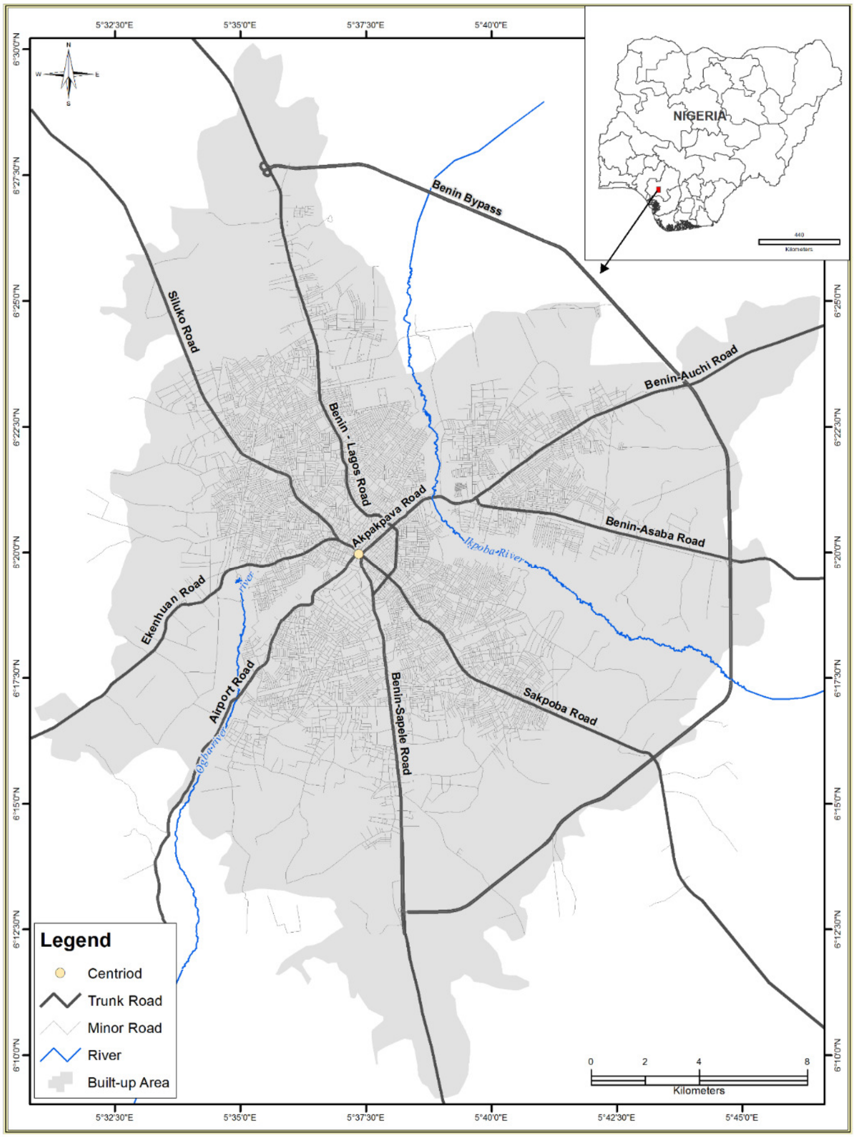

Figure 1: Benin metropolitan region (Modified from Nkeki, 2018)

2.2. Data Collection

The data required for modelling travel mode choice and individual-related characteristics is often disaggregated at the household level. Hence, structured questionnaires were administered to selected households of BMR on the bases of multistage probability sampling method (Whittemore and Halpern, 1997). Using the central limit theorem sample determination procedure based on Lenth, (2016), a total of 1836 households were selected from the study area for the sampling. This is the optimal sample size with a margin of error of 0.03 (± 3%), 99% confidence level and an estimated total number of households of 248,621 (NPC, 2006).

The study region was stratified into 55 neighbourhoods from where 55 streets were further extracted. The segmentation of the questionnaires was done in such a way that an average of 33 questionnaires was administered in each of the sample locations in the delineated neighbourhoods on the basis of systematic sampling technique. Questions on travel-related activities, residential location preference and other neighbourhood characteristics were presented to the heads of household or their spouse. The participant for each household is a person who works more than 10 hours in a week who is neither retired nor a full–time housewife, whose travel origin and destination is in the study region and who starts and ends his or her daily trip at home location (hereafter referred to as a commuter).

2.3. Analytical Techniques

The hypothesis that travel mode choice is not significantly influenced by preferences for residential location was tested with a discrete choice model. Binomial logit model which belong to the family of discrete choice models was implemented in this study to determine the significance of the hypothesis and assess the degree of influence that residential location preference may wield on individual travel mode choice.

The travel modes of interest in this study are motorized and non-motorized mode of travel to work. The reason for this analysis is to investigate the role of residential neighbourhoods in influencing people's desire to drive or walk. In this study, it is assumed that the choice for residential neighbourhood is to a large extent a function of the decision maker's demographic and socioeconomic characteristics, and to a lower extent a function of the neighbourhood characteristics. However, the decision to walk or to drive may be directly influenced by neighbourhood choice.

Binomial logit model has been used by many researchers to explore travel mode choice among two independent alternatives (Muley *et al*., 2009; Guoqiang and Wang, 2012; Zahabi *et al*., 2012; Asikhia and Nkeki, 2013). The model allows binary outcomes for a dependent variable and one or several explanatory variables in any of continuous, categorical responses, etc. The binary outcome uses a nominal scale of 0 and 1 or yes and no coding to represent individual responses i.e. the probability must be between 0 and 1. In this case, 1 and 0 were coded for motorized and non-motorized modes respectively. However, the explanatory variables to be used here comprise the factors of residential location preference highlighted in Table 1. In addition, Table 1 also include the disaggregated mode types coded into motorized and non-motorized modes.

Table 1: Variable names and coding for binomial logit model

Variables	Description
Independent	
1. Socio–distance	1 = Proximity to relatives 2 = Proximity to hometown/ village of origin
2. Neighbourhood design	1 = Safety and security 2 = Good road network 3 = Clean and well–planned 4 = Availability of sidewalk
3. Accessibility	1= Proximity to workplace 2 = Access to good school 3 = Proximity to the place of worship 4 = Access to cheap accommodation 5 = Proximity to expressway
Dependent	
4. Motorized	1 = Car, taxi, bus, tricycle
5. Non-motorized	0 = Walk on foot

2.4. Model Specification

In the model's specification of the binomial logit model, the covariates X to X_n is considered to be the factors (social–distance, neighbourhood design and accessibility) of residential location preference that may contribute to the probability of commuting to work by either motorized mode or non-motorized mode. The variables are depicted mathematically as:

$Y =$ binary response variable (mode choice)
$Y_i = 1$ if the choice is present in observation i (commuter)
$Y_i = 0$ if the choice in not present in observation i

$X = (X_1, X_2, \cdots, X_n)$ a set of explanatory variables which can be discrete, continuous, or a combination. x_i is the observed value of the explanatory variables for observation i.

The model formulation is:

$$\pi_i = Pr(Y_i = 1|X_i = x_i) = \frac{exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n)}{1 + exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n)} \quad (1)$$

Where:
π_i = the logit
Pr = probability of Y occurring
β_0 = interception at y–axis
β_1 = line gradient
β_n = model's coefficient of X_n
$X_1 - X_n$ = predictor variables

The interpretation of the model was based on the odd ratio and likelihood, Wald statistic and parameter estimate. SPSS analytical software was used to perform the computation of the binomial logit model.

3. RESULTS AND DISCUSSION

3.1. Descriptive Statistics

A total of 1736 observations was considered valid cases of the 1836 households that were engaged in the questionnaire survey. The result of the survey shows that households that depend on motorized mode for their work-related travel largely dominate the mode split with 59.4% while those that depend on non-motorized mode falls within the other half (40.6%). The neighbourhood-level comparison (Table 2) shows that, Igue-Iheya, Aduwawa, Ovbiogie and Iguosa are the highest motorized mode dependent neighbourhoods with 96%, 95%, 90% and 87% values respectively. On the other hand, Iyanomo, Avbiama, Evbogida and Urumwon are the highest non-motorized mode dependent neighbourhoods with a corresponding percentage values of 70, 65, 65 and 62.

Table 2: Neighbourhood-level mode choice

Name of neighbourhood	Non-motorized (%)	Motorized (%)
Adesogbe	33.3	66.7
Aduwawa	5.0	95.0
Amagba	31.4	68.6
Avbiama	64.7	35.3
Egbean	35.5	64.5
Egor	38.5	61.5
Ekae	52.8	47.2
Ekosodin	38.7	61.3
Evbogida	64.5	35.5
Evbomore	30.3	69.7
Evboriaria	19.4	80.6
Evbotubu	41.9	58.1
Evbuabogun	37.1	62.9
Evian	40.7	59.3
Ewah	35.3	64.7
Eyaen	25.9	74.1
Idogbo	51.9	48.1
Idokpa	48.1	51.9
Idumwunivbioto	54.3	45.7
Idunwowina	33.3	66.7
Igue-Iheya	4.0	96.0
Iguomon	32.3	67.7
Iguosa	13.3	86.7
Ikhue-niro	37.0	63.0
Ikpoba hill	50.0	50.0
Isiohor	37.1	62.9
Iwogban	32.0	68.0
Iyanomo	70.4	29.6
King Square	59.4	40.6
Obazagbon	62.5	37.5
Obe	57.6	42.4
Ogba	52.6	47.4
Ogbeson	40.0	60.0
Oghede	50.0	50.0
Ogua	48.6	51.4
Ohovbe	33.3	66.7
Oka	61.8	38.2
Okhokhugbo	53.1	46.9
Okhoro	17.1	82.9
Okhunmwum	50.0	50.0
Oko	48.6	51.4
Oluku	31.0	69.0
Oregbeni	35.5	64.5
Ovbiogie	9.7	90.3
Ubagbon	54.6	45.4
Ugbekun	37.5	62.5
Ugboikhiko	40.0	60.0
Ugbowo	34.3	65.7
Umelu	55.6	44.4
Urubi	44.1	55.9
Urumwon	61.5	38.5
Useh	51.6	48.4
Uselu	23.3	76.7
Uwelu	33.3	66.7
Uzebu	31.2	68.8

3.2. Model of Residential Location Preference and Travel Mode Choice

A binomial logit model was used to analyze the data and also to test the hypothesis. Various statistical parameters were used to test the model's fitness so as to ascertain its appropriateness for the data.

3.2.1. Testing the model's appropriateness and hypothesis

The fitness test was carried out with Hosmer and Lemeshow goodness-of-fit test statistic (χ^2). The fitness statistic states that a binomial model is poorly fitted when the Hosmer and Lemeshow significant value is less than 0.05. In this model, the goodness-of-fit statistic value was 1.000 (Table 2) which is greater than 0.05. The *pseudo* of 0.081 shows a generally low performance though this is acceptable for a disaggregated model with a categorical response.

The hypothesis was tested with the Omnibus test of the model coefficient (χ^2). The null (H_0) indicates that travel mode choice of commuters has no significant relationship with a preference for residential location. The χ^2 statistic suggests that the H_0-hypothesis must be rejected at α (alpha) confidence level of 0.05 while the alternative H_1 must be accepted. Since the χ^2 Omnibus statistic returned a value of 107.031 with a corresponding significant α value of 0.000. This means that in BMR, the desire to choose between motorized and non-motorized mode of travel is significantly influenced by residential location preference.

3.2.2. Motorized and non-motorized mode choice model's estimation

Table 3 present the result of individual predictors as they explained the motorized mode choice and concurrently makes inference for non-motorized mode. Eleven predictors were entered into the analysis. Of these, three returned significant values at 0.05 confidence level. None of the socio-distance variables were significant, while accessibility variable group returned two significant predictors. The neighbourhood design variable group returned one significant predictor. However, only the significant predictors were discussed here and these are good road network, proximity to workplace and proximity to expressway.

The model's result shows that good road network strongly prompt commuters to choose between motorized and non-motorized mode of travel to work. The parameter estimate of the empirical model shows that good road network significantly increases the likelihood of commuting by motorized mode. Good road network increases the odds ratio by roughly 3 times, meaning that good design structure may encourage commuters to depend on motorized mode 3 times more. As expected, proximity to workplace seems to discourage dependence on motorized travel mode. The model's result revealed that those who prefer to reside in the neighbourhood close to their place of work may likely choose to commute by non-motorized mode. Proximity to expressway returned a positive significant relationship and this indicates that those who prefer to live in a neighbourhood close to expressway may likely choose to travel to work with the motorized mode. The closer that neighbourhood is to the expressway, the higher the odds ratio, precisely 7.3 times more likely to depend on motorized travel mode.

The finding from the hypothesis which was tested with the χ^2 statistic of binomial logit model shows that in the region, the desire to choose between riding on motorized mode of travel and non-motorized mode is significantly influenced by residential location preference. This result is somewhat consistent with that of several studies which emerged in recent times. For example, Boarnet and Crane, (2001) argued that people choose their residential location based on their desired driving patterns as persons who dislike driving might both drive less and choose to live in a high density, mixed land use neighbourhood that supports alternative mode other than driving. Many other authors have argued that the built environment instigates people in choosing where to live based on their travel needs and preferences (Parra *et al*., 2010; Friedman *et al*., 2012; Cao, 2013; Cao, 2014). Contradicting this, Chatman (2014), strongly argued that the common conception of residential self-selection in relation to the built environment and travel behaviour is in error. In support of

Chatman (2014), this study revealed that residential location in relation to travel behaviour should be treated at the individual level because people choose where to live as it corresponds to their travel needs. Hence, binomial logit model here was tailored to capture the individual preferences of residential location and how it influences such individual's travel mode choice instead of using the physical neighbourhood design and general land use structure alone to conclude on people's desire.

Table 3: Binomial logit model of motorized and non-motorized travel mode choice

Variables	B	Std. Error	z–stat	Wald	Odds Ratio
Proximity to relatives	–0.171	0.514	–0.33	0.11	0.843
Proximity to hometown	–0.634	0.500	–1.27	1.61	0.530
Safety and security	–0.001	0.481	–0.00	0.00	0.998
Good road network	1.215	0.597	2.03*	4.14	3.370
Clean and well–planned	0.665	0.609	1.09	1.193	1.944
Availability of sidewalk	0.154	0.988	0.16	0.024	1.167
Proximity to workplace	–0.869	0.489	–1.98*	3.166	0.419
Access to good school	1.166	0.722	1.61	2.605	3.208
Proximity to place of worship	0.559	0.702	0.80	0.635	1.750
Access to cheap accommodation	0.049	0.507	0.10	0.009	1.050
Proximity to express way	1.987	0.875	2.27*	5.152	7.291
Constant	0.539	0.476	1.13	0.873	1.714
Model's fitness parameters					
No. of cases	1735				
–2 Log likelihood	2236.189				
ρ^2 (pseudo)	0.081				
The omnibus test of the model coefficient (χ^2)	107.031				
p–value	0.000				
Hosmer & Lemeshow test (χ^2)	1.000				

Note: *significant parameter at 0.05

The finding of this model shows that residential neighbourhoods composed of good road network are a preference for commuters to patronize motorized modes. It was also discovered that those who prefer to reside close to their place of work may likely patronize non-motorized modes. The basic reason for such co-location of residence and workplace is to avoid extra cost on travel to work. This undoubtedly encourages walking or non-motorized mode. This finding is consistent with the works of Cervero and Duncan, (2002) and Cao *et al.* (2006). This finding also conforms with the co-location hypothesis and may serve as a useful result as that expected from the US-based *New Urbanism* concept that seeks to plan urban area so that jobs and homes of workers would co-locate creating a dense city that would be friendly to non-motorized mode of travel.

Another finding revealed by the binomial logit model is that commuters who prefer to reside close to the expressway do so for the purpose of accessibility and for motorized mode efficiency. This finding is in conformity with the result of several studies conducted in the US. For example, Limtanakool *et al.* (2006) found out that proximity to linear infrastructure is one of the built environment variables that influences travel. Others are Kitamura *et al.* (1997) and Cervero, (2002). Most likely, people who choose to reside in certain neighbourhood simply because it is close to an existing expressway may not concern themselves with distance since the majority of them may depend on motorized mode of travel. These commuters are often found in the suburban neighbourhood of the city (neighbourhoods close to expressway are the least accessible from the CBD, Nkeki (2018)) and their preference for such residential neighbourhood is because of concern for their cars. They choose such neighbourhood because they depend on motorized mode or probably believe that their mode choice would change in no distant future since they can afford to own a car. It is not surprising to find this character of people clustered in similar neighbourhoods. This is supported by the result of the descriptive analysis (Table 2) that identified three major car dependency neighbourhoods

(Iguosa, Igue-Iheya and Ovbiogie) and these neighbourhoods are located along a high priority expressway at the periphery of the region with least accessibility to the urban core. These neighbourhoods are 13 to 16 km average distance from the CBD (Nkeki, 2018).

4. CONCLUSION

The findings of this study present useful policy and planning implications for urban transport and land use planning in BMR. The major transport planning issue in this area of research is to learn how to reduce motorized mode dependence for urban travel. Formulating and implementing strategic policy to encourage more workers to walk to work will go a long way to cut down the heavy reliance on motorized travel mode. Since the decision to choose between motorized and non-motorized mode of travel is strongly influenced by the preference for residential location, planning ideology need to be focused on land use restructuring, reconfiguration and enforcement of existing planning laws to ensure compliance especially among land developers. For example, one of the findings of this study revealed that living close to work location would inspire people to patronize non-motorized mode. The implication of this is that formulating and implementing a strategic policy that would bring workers close to their place of work may be a sustainable measure of reducing motorized mode specifically car use. This is in accordance with a global concept such as the co-location hypothesis.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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