

## Does urban form influence automobile trip frequency in Accra, Ghana?

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**Abstract:** Sustainable mobility is gaining increasing attention as it is seen as an approach to effectively reduce automobile travel and simultaneously encourage other modes of travel. To this end, it is imperative that scholars provide planners and policymakers with adequate empirical evidence to enable them to make informed decisions. In this sense, this study attempts to understand how socio-demographics, urban form (town center proximity-walk accessibility and other locational characteristics), perception and satisfaction pertaining to public transport influence automobile trip frequency. It particularly employs a partial least square structural equation modelling approach with the aim of appreciating the complexities in the land use-travel behavior interaction with the aid of data from the 2012 National Household Travel Survey of Ghana. The paper finds that the main explanatory factors identified in the land use-transportation-travel behavior literature are deemed significant in the case of Accra with socio-demographics yielding the largest magnitude. Also, public transport satisfaction turns out to have a negative influence on automobile trips.

**Keywords:** automobile trip, urban form, perception, satisfaction, partial least squares structural equation modelling, Accra

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## 1 Introduction

The end of the 20th century has seen the concept of compact urban form make enormous waves because it has been considered a pathway for creating sustainable cities that are not automobile dependent. The trajectory of research on sustainable urban form can be attributed to the increasing environmental and social challenges the world is facing (Lee & Lee, 2014; Ye et al., 2015) and Ghana is definitely not an exception. Sustainable urban form is regarded as an alternative to urban sprawl as it has the potential to reduce transportation energy, minimize noise and create a cleaner atmosphere as a result of the reduced usage of automobiles and the incorporation of non-motorized forms of travel in particular (Frumkin, 2002; Nakamura & Hayashi, 2013).

Despite the fact that sustainable urban form has received much attention in the Global North (North America and Europe) (Schwanen, Dieleman, & Dijst, 2004; Sultana & Weber, 2007), the same cannot be said for the Global South with special reference to Africa. This can be inferred from

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the relatively few studies in this area. As urban form affects the spatial distribution of human activities, it is important to understand how such form influences travel behavior of people. Some scholars have attempted to examine the relationship between the built environment and travel behavior, which is expressed in terms of the choice of travel mode, frequency of trips, and distance of travel (Ewing & Cervero, 2010; Gim, 2013). Stevens (2017) has identified key components of urban form that have the potential to influence travel behavior. Among such variable includes density (population and street intersections), distance to transit, and mixed land use among others. The purpose of this study is to examine how socio-demographics, town center proximity–walk accessibility, and other locational characteristics influence an individual's travel behavior and to ascertain whether studies conducted in the Global North can be applicable to the case of Ghana. What makes this research unique is that it includes satisfaction and perception variables in the land use–travel behavior relationship. This paper uses partial least square (PLS) structural equation modelling (SEM) to examine the relationship, which is evaluated with data from the 2012 National Household Travel Survey of Ghana (NHTS-G). This paper contributes to the expansion of the literature by including an African perspective as well as by incorporating satisfaction and perception variables in the complex land use–travel behavior interaction. The main limitation of this study is that it analyzed only an aspect of travel behavior which is automobile trip frequency.

## 2 Literature review

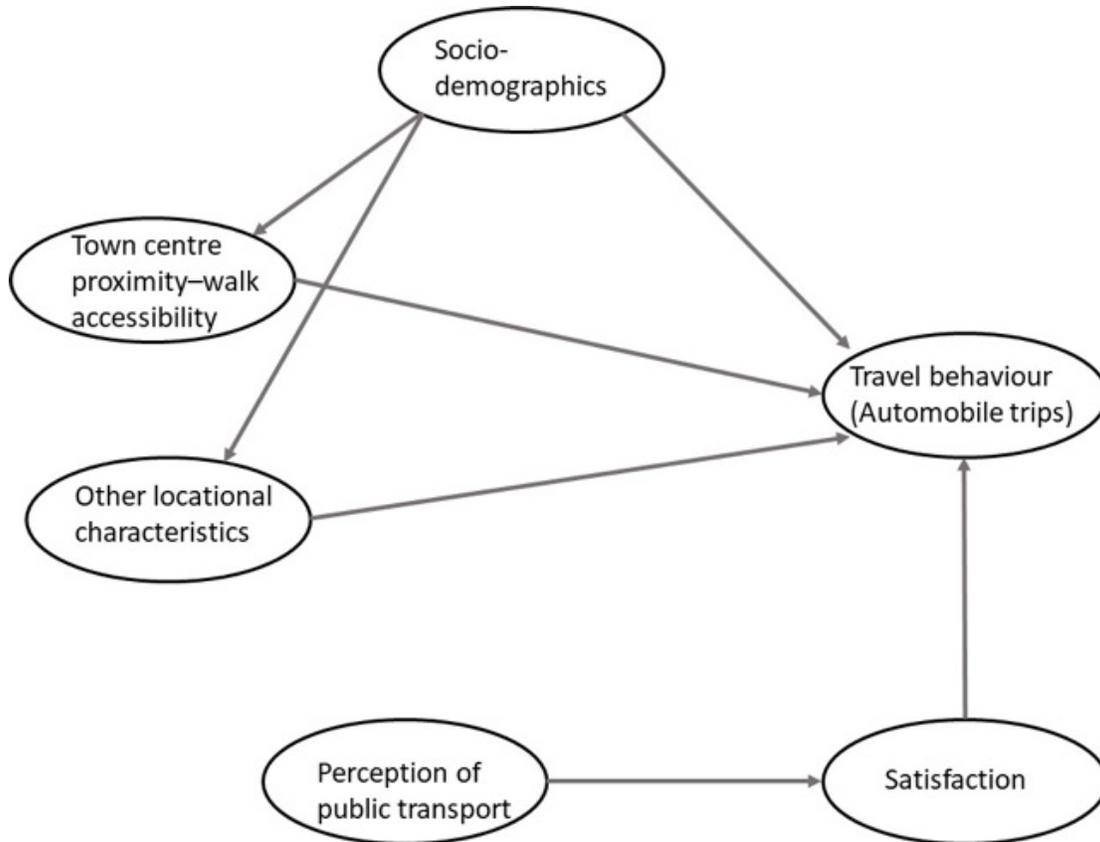
Several theories and models have been advanced to elucidate travel behavior. Famous among them is the microeconomic utility theory. This has been the underpinning theory upon which most travel behavior-related studies have been undertaken (Handy, Boarnet, Ewing, & Killingsworth, 2002). The theory advances the argument that people are forced to make trips because of the non-uniform spatial distributions of activities. Thus, one can derive travel demand as a result of engaging in activities away from their current location. Another concept that is gaining popularity in the field of travel behavior is subjective well-being (SWB). This concept better encapsulates a person's preference with regards to the mode of travel as it is able to directly account for abstract items such as personal feelings, sentiments and perceptive judgment (Kahneman & Krueger, 2006; Kahneman, Wakker, & Sarin, 1997). SWB represents the perception of all available resources that are essential for an individual's well-being and enables positive emotions (Diener & Biswas-Diener, 2008). There is a growing interest among transportation researchers in the area of SWB. This measurement construct together with others have been extensively developed and validated in the field of psychology. In recent decades, a number of scholars (Ettema, Gärling, Eriksson, Friman, Olsson, & Fujii, 2011; Stradling, Anable, & Carreno, 2007) have employed SWB as a measure of travel satisfaction. Satisfaction can be considered one of the key elements which have the potential to influence an individual's modal choice as well as trip frequency via a particular mode. Accordingly, recent studies (Cao & Ettema, 2014; Ettema, Friman, Gärling, Olsson, & Fujii, 2012; Mokhtarian, Papon, Goulard, & Diana, 2015) have attempted to explore the purported connection between travel characteristics—for example, duration of travel, mode of choice, and trip frequency—and travel satisfaction.

The definition of sustainable urban form has remained vague over the years as scholars and practitioners have failed to come to a consensus on this issue. Ewing (1997) suggests that this concept should consist of components such as land-use mix, employment, and residential concentration. Others argue that it should be an embodiment of development clusters to help control the usage of land; thus, this is an advancement of compact development (Galster et al., 2001). Cities found in the Global South often have a monocentric urban form, implying that facilities and services are generally centralized in and around the city's core (Cervero, 2013; UN-Habitat, 2011). As a consequence of this phenomenon, a sizable proportion of urban dwellers live further away from such facilities, necessitating them to travel for

the purpose of accessing such facilities. Ghana's urban form can be described as above (Doan & Oduro, 2012; Cobbinah & Amoako, 2014; Acheampong, Agyemang, & Abdul-Fatawu, 2017). With this type of urban form, trip utility is not derived from travel demand exactly, but rather the urgency to reach an activity location of interest (van Wee, 2002, p.260). According to van Wee, people try to make rational choices with regards to the means that they should take to reach their destination and simultaneous arresting "travel resistance" which is reflected in cost—in monetary terms and time (van Wee, Baker, & Van der Hoorn, 1997). However, human decisions are not always rational due to incomplete information, so some level of subjectivity can be found in the decision-making cognitive process, which reflects the person's society and values he or she is engulfed in.

Different parameters of urban form have been used in the process of examining the influence of the urban form on travel behavior: They include population density (Huang, Lub, & Sellers, 2007), urban block or neighborhood design (Sung, Lee, & Cheon, 2015), neighborhood accessibility (Banerjee & Hine, 2016; Cao, Mokhtarian, & Handy, 2007), and residential density (Etminani-ghasrodashti & Ardeshiri, 2015). Regarding travel satisfaction, other studies attempted to ascertain the link between travel attitude (St-Louis, Manaugh, van Lierop, & El-Geneidy, 2014) or the built environment (Cao & Ettema, 2014; De Vos, Mokhtarian, Schwanen, Van Acker, & Witlox, 2016) and travel satisfaction.

Over the span of three decades, there has been an expansion of variables that have been used to investigate the travel behavior phenomenon, including urban form and socio-demographic (Agyemang, 2017; Handy, Cao, & Mokhtarian, 2005; Stead, 2001). Handy et al. (2005) examined how attitudes and socio-demographics influenced urban form parameters. Handy et al. (2005) also noted that people's attitude and sociodemographic differentiate the choice of their residential neighborhoods. They found that there is an appreciable level of causality between some of the three factors, including one between socio-demographics and urban form; this is known as residential self-selection. Scholars have confirmed the occurrence of residential selection bias via empirical investigations (Cao et al., 2007; Handy et al., 2005; Sultana & Weber, 2007). The bias can lead to the misestimation of urban form influences on travel behavior. Urban form can be seen as a mediator (Krizek, 2003) in the land use-travel behavior interaction (see Figure 1). By contrast, some studies recognized urban form as a stand-alone construct that is composed of objective and perceived parameters (Bagley & Mokhtarian, 2002). Also, residential self-selection does not only exist in travel behavior studies but also in medical studies where socio-demographics and attitudinal variables have been modelled with urban form (Saelens, Sallis, & Frank, 2003). Notably, this study did not directly control for residential self-selection, especially attitudinal characteristics, which is a limitation of this study. [Other parameters which have been identified to have an effect on travel behavior—particularly in Ghana—includes transit and parking availability (Frank, Bradley, Kavage, Chapman, & Lawton, 2008; Messenger & Ewing, 1996).



**Figure 1:** Conceptual framework

Note: This study began with a single urban form construct, but to make the analytical PLS-SEM model reach an acceptable fit regarding the discriminant and convergent validity, the authors separated the construct into (1) town center proximity-walk accessibility and (2) other locational characteristics. The separation was based on common factor analysis as often used before fully running SEM (Gim, 2015; 2018). (See Figure 5 and Tables 2 and 3).

Satisfaction and perception variables were included in this study as it is gradually gaining grounds in travel behavior research. Many scholars (Lorenz, 2018; Dickerson, Hole, & Munford, 2014; St-Louis et al., 2014) have attempted to understand how changes in SWB relates to specific issues. In relation to travel behavior, one can ask whether SWB can change as a result of variations in travel behavior (e.g., improved service of public transit delivery or change in the mode of travel) (Ettema et al., 2011; Ettema, Gärling, Olsson, & Friman, 2010).

SEM is increasingly popular in the built environment and travel behavior analysis. This study employed PLS-SEM, in particular. This approach affords researchers to explore unique constructs and their corresponding indicators which might be either objective or perceived or both as they attempt to model the complex interaction of the travel behavior phenomenon (Ma, Dill, & Mohr, 2014). This is usually done with the help of pathways shown in the conceptual framework or research model. The PLS-SEM approach has been employed in a number of studies (Banerjee & Hine, 2016; Gehrke & Clifton, 2017; Gim, 2011) to explore the potential or hypothesized relationships between identified constructs and travel behavior. Several studies have attempted to investigate different aspects of urban form and how such constructs influence the trip frequency and travel mode choice. For instance, physical characteristics of a neighborhood (Aditjandra, Cao, & Mulley, 2012; Aditjandra & Mulley, 2016; Banerjee & Hine, 2016), its accessibility to local/regional major destinations (Cao, 2016; Cao, Mokhtarian, & Handy, 2007), the perception of a place (Deutsch, Yoon, & Goulias, 2013), and its influence on vehicle ownership as well as on the choice of preferred travel mode.

In a study conducted in Seoul, South Korea, Gim (2011) identified six reflective constructs among which urban form included proximity to transit, land-use mix, and density. Other constructs considered in his model were socio-demographics and attitudes. In another study conducted in the San Francisco Bay Area (Bagley & Mokhtarian, 2002), the authors attempted to measure the extent to which one's lifestyle, neighborhood characteristics and perception of distance of travel via different means (public transit, automobile, etc.) are influenced by the type of the environment one resides in, be it suburban or traditional. That is, as, in Table 1, the literature shows a wide variety of perceived and objective constructs of urban form. This can be attributed to the fact that homogeneity in residential and locational characteristics almost always does not exist. As such, urban form constructs need to be tailored to correctly estimate the urban form effect of a particular phenomenon of interest rather than taking a generalized construct (de Abreu e Silva, Morency, & Goulias, 2012). Thus, this study had to tailor the urban form variables to suit the study area.

**Table 1.** Urban form variables and statistical techniques used in travel behavior studies

Author(s)	Study area	Urban form variables examined (Socio-economic & demographic variables were included)	Statistical analysis	Residential self-selection examined
Agyemang, 2017	Africa (Ghana)	Distance	Multinomial logit model	-
Gehrke & Clifton, 2017	USA	Density, Diversity, Design	SEM	No
Ding, Wang, Liu, Zhang, & Yang, 2017	USA	Distance, Diversity	SEM & Discrete Choice Model	No
Zhang & Zhang, 2017	USA	Density, Diversity, Design	Multinomial logit model	-
Banerjee & Hine, 2016	UK	Distance, Diversity	PLS-SEM	Yes
Gim, 2016	Asia	Density, Distance, Attitude	SEM	-
Gim & Joohno, 2016	Asia	Distance, Density, Diversity	Logistic regression	-
Etmnaini-Ghasrodashti & Ardeshiri, 2015	Middle East	Density, Distance, Design	SEM	-
Easton & Ferrari, 2015	UK	Distance, Diversity	Markov Chain Monte Carlo (MCMC)	No
Zahabi et al., 2015	Canada	Density	Latent class regression analysis	Yes
Ewing et al., 2014	USA	Density, Diversity, Design	Multilevel modelling & Hurdle models	No
Guerra, 2014	South America (Mexico)	Diversity, Destination, Density	Tobit regression	No
Majid et al., 2014	Asia	Density, Diversity, Design, Destination	Multiple regression analysis	No
Salon et al., 2014	USA	Design	Tobit regression	Yes

<b>Asad, 2013</b>	UK	Distance	Generalized linear model & Factor analysis	Yes
<b>Ewing et al., 2013</b>	USA	Destination, Design, Diversity	Hierarchical linear model	No
<b>Nasri &amp; Zhang, 2012</b>	USA	Destination, Design, Diversity	Multilevel mixed effect regression	No
<b>Zhang et al., 2012</b>	USA	Density, Destination	Multilevel Bayesian regression	No
<b>Boarnet et al., 2011</b>	USA	Density, Destination, Diversity	Regression	No
<b>Heres-Del-Valle &amp; Niemeier, 2011</b>	USA	Density, Diversity	Two-part model (regression model)	Yes
<b>Naess, 2011</b>	EU	Design, Distance, Destination	Bivariate & partial correlation	Yes
<b>Cao, 2010</b>	USA	Design, Distance	Binary logistic regression	Yes
<b>Brownstone &amp; Golob, 2009</b>	USA	Density	Simultaneous equation	
<b>Cao et al., 2009</b>	USA	Distance, Destination, Density	Discrete choice model & SEM	Yes
<b>Ewing et al., 2009</b>	USA	Diversity, Destination	-	-
<b>Frank et al., 2009</b>	USA	Diversity, Design, distance	-	No
<b>Greenwald, 2009</b>	USA	Density, Diversity, Design, destination	-	No
<b>Sultana &amp; Weber, 2007</b>	USA	Density, Design	Multi equation 2 (OLS)	-

### 3 Methodology

#### 3.1 Study area

As the national capital, Accra is located in the Greater Accra Region and it is the smallest region<sup>1</sup> (1.4%) in Ghana (Ghana Statistical Service, 2013). See Figure 2 for the map of Ghana after the creation of new regions. Accra's urban extent in 1991 was about 133.24 km<sup>2</sup> and it increased at an average annual rate of 12.4% to reach 412.41 km<sup>2</sup> by the year 2000. However, the rate of increase reduced to 5.3% from 2000 to 2014. By 2014, Accra's urban extent hovers around 872.12 km<sup>2</sup>. Over the last century, Accra has continuously experienced an increase in its population ever since it became the capital of the country: It has had an annual growth rate of 4% between 1984 and 2000 (Ghana Statistical Service, 2002). This made it one of the fastest-growing metropolis on the African landscape (UN-Habitat, 1999). However, the estimated population growth rate has witnessed a nosedive as the annual growth rate between 2005 to 2018 has almost halved (2.13%) (World Urbanization Prospects, 2018). At the time of independence in 1957, Accra's population was 190,000 and it increased to 1 million in 1984 and has sky-rocketed to

<sup>1</sup> The Greater Accra Region remains the smallest region in Ghana even after the creation of new regions by the Government of Ghana in 2018 (<https://www.citypopulation.de/en/ghana/cities/>).

1,658,937 in 2000 (Ghana Statistical Service, 2002). From 2005 to 2019, the population of Accra has increased from 1,853,807 to 2,475,208 and this represents 33.58% increase within the 19-year period (World Urbanization Prospects, 2018) as Accra continues to extend its urban area as a result of conurbation.

The built-up area density in Accra has been decreasing steadily since the 1990s. In 1991, Accra had a built-up area density of about 130.49 persons/ha. By the year 2000, the percentage of the built-up area density was pegged at 78 persons/ha. The built-up area density continued to reduce at an average annual decreasing rate of about 0.6 percent between 2000 and 2014. Thus, as of 2014, the built-up area density is 72 persons/ha. This suggests the sprawling nature of Accra's urban extent (refer to Figure 3).

The road transportation sector has dominated the urban landscape as it is estimated to move 22 million people and 122 million metric tons of goods every year (Agyemang, 2009). Recent estimates shows that road transport accounts for 97% of passenger and 94% of freight transportation in Ghana (Okyerere, Yang, Aning, & Zhan, 2019) and this explains why the country spends 1.5% of its annual gross domestic product on road infrastructure which makes it the highest in the West African sub-region (Eng-larsson & Kohn, 2012, as cited in Okyerere et al., 2019). The road network system found in Accra has the characteristics of a radial route where the majority of road networks converge at the central business district (CBD) (Addo, 2002). Addo (2002) argued that with this kind of road network, connectivity is particularly low between the east-west corridors. Figure 4 helps one to appreciate the extent of connectivity as it illustrates the intersection density count of Accra.

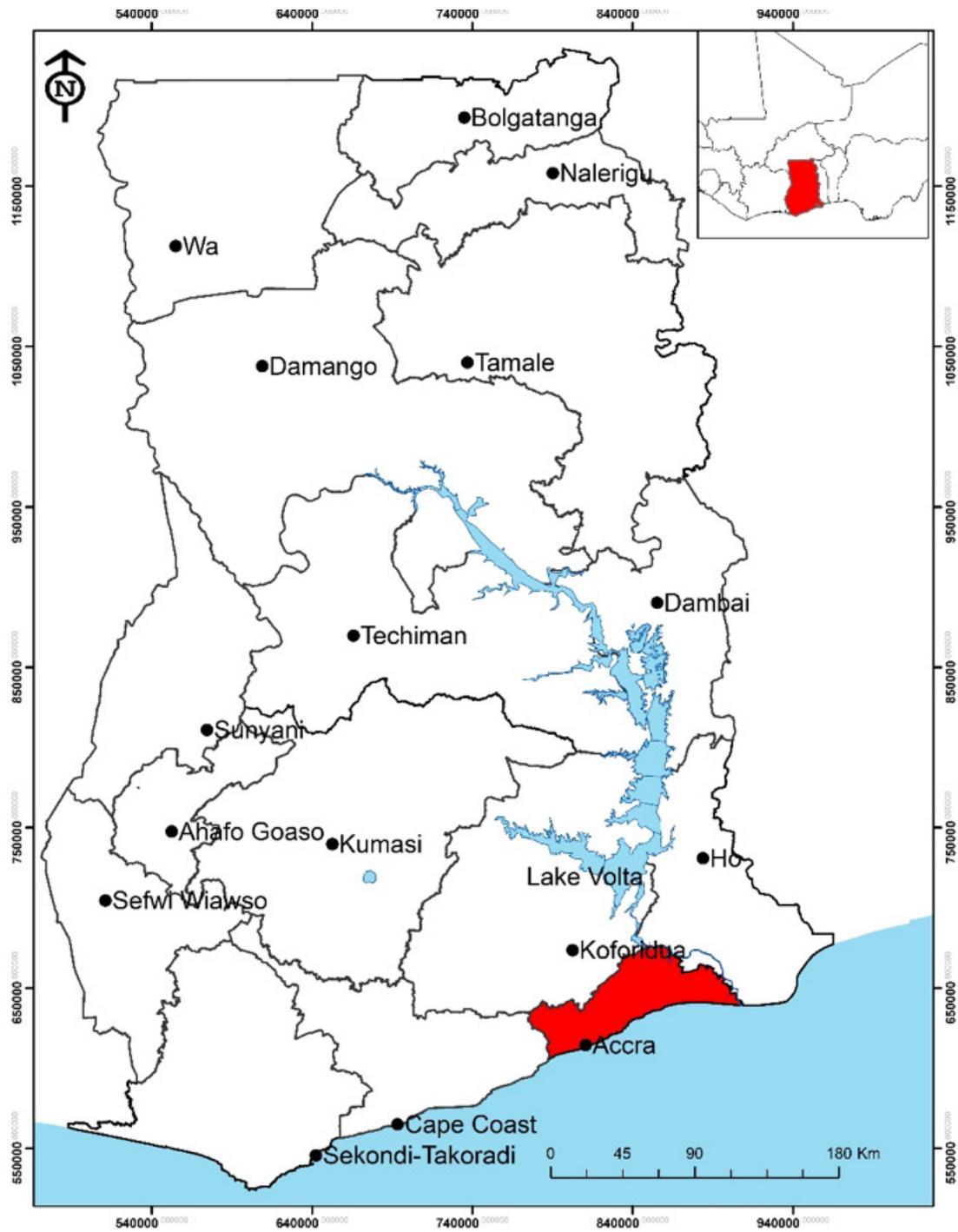
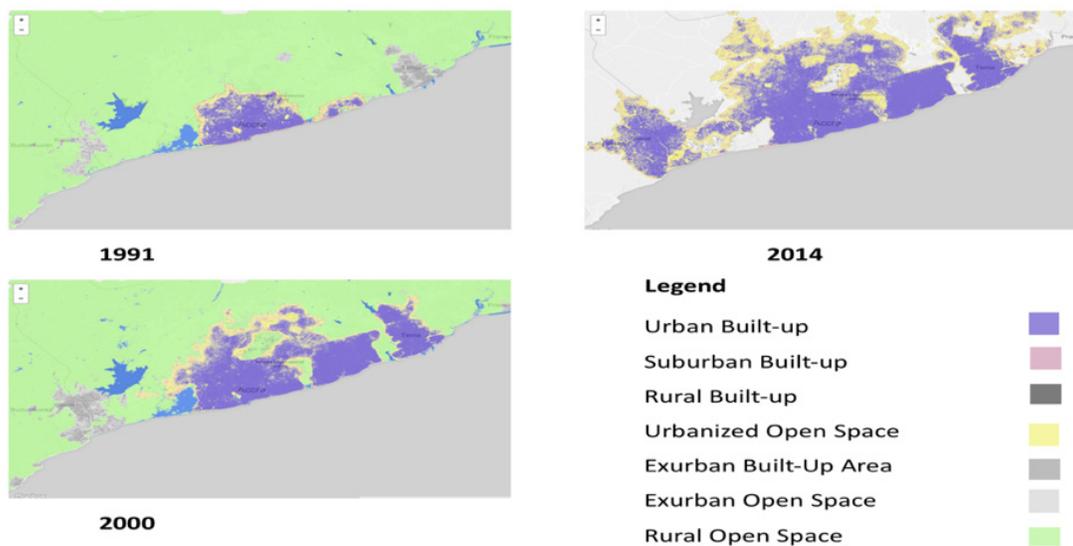


Figure 2. Map of Ghana in the West African context



Source: Atlas of Urban Expansion (2016).

Figure 3. Changes in the urban extent of Accra (1991 to 2014)

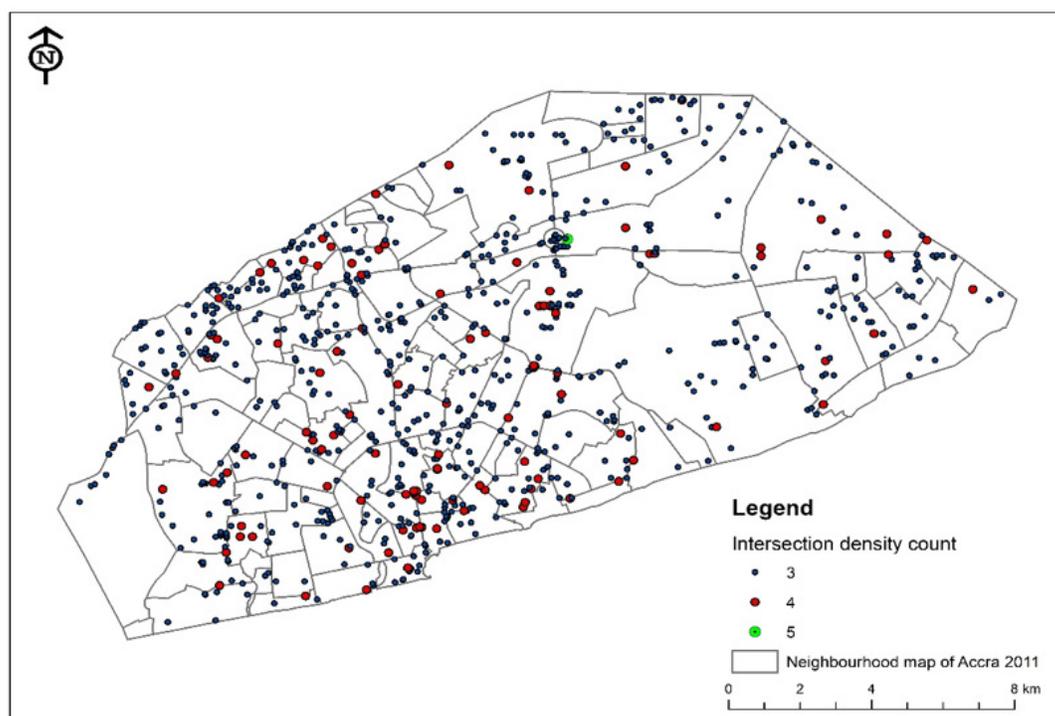


Figure 4. Neighborhoods and road intersections of Accra

### 3.2 Data

Data for this study was extracted from the 2012 NHTS-G, which was the second nation-wide transport survey conducted by the Ghana Statistical Service (GSS). Data collection spanned for a period of 3 months (from 1/9/2012 to 31/12/2012). The survey was conducted via face-to-face interviews, that is, field workers collected answers to the survey questionnaire through their personal visit of each respondent's residence. Accordingly, the survey achieved a very high response rate (99.93%). For the purpose of this research, the NHTS-G data were trimmed as follows. 6000 Households from 400 enumeration areas were deemed as representative and sufficient sample for the entire nation by GSS. Within an enumeration area, 15 households were randomly selected. It should be noted that these random selections were categorized into rural and urban areas. For the purpose of this study, only urban areas within the Greater Accra Region were selected (Accra to be specific). As the data had already been grouped under rural and urban, the authors focused on the urban sample for their analysis. Respondents who were less than 18 years old were excluded from the final analysis. Missing data were dealt with by means of the multiple imputation method (MI) as 15.872% of the variables were impacted. As the focus of employing the MI method is to make the data valid to be able to draw statistical inference (Schafer, 1997), the default parameter (MI method was automatic) was used. Under the method for the imputation of missing data, the default parameter was selected for the algorithm to scan and choose an appropriate imputation method (i.e., choosing between the fully conditional specification [also known as the Markov Chain Monte Carlo method (MCMC)] or the monotone method and whether to engage two-way interaction among categorical predictors as well as whether to use the linear regression or the predictive mean matching. The iterative MCMC method is engaged in situations where an arbitrary missing data pattern exists, whereas with the monotone noniterative method, variables can be arranged in a way that when associated values of a variable are intact, all other variables that come before it also have no missing values. Concerning constraints, we engaged the 'impute only' but not 'impute and use as a predictor' option to ensure the soundness and compactness of the model with the express aim to minimize errors. Ultimately, a sample of 487 adults was used to carry out an empirical analysis (as of 2012, 1,214,414 adults live in the Greater Accra Region). In this sense, the sampling rate based on the effective sample is 0.04%). On average, they embarked on 0.304 trips (S.D. = 2.567, minimum = 0, and maximum = 70).<sup>2</sup> It should also be noted that the data used for this study is an open-sourced data and it can be found at Ghana Statistical Service's website.

### 3.3 Statistical method: PLS-SEM

SEM can specify causal relationships to test/confirm theories, concepts, and empirical findings (Hair, Ringle, & Sarstedt, 2011; Lowry & Gaskin, 2014). Most travel behavior studies have used more traditional covariance-based SEM (CB-SEM); it is usually referred to as SEM (Van Acker & Witlox, 2010). However, this study used PLS-SEM due to the complex relationships among its latent variables (CB-SEM often mandates an unpalatable simplification of the conceptual relationships). Another unique attribute of PLS-SEM is that it relaxes assumptions as to the nature of data distribution and sample size required to carry out analyses (Vinzi, Trinchera, & Amato, 2010; Hair et al., 2011). Wold (2006) argues that what makes PLS-SEM more appealing than the CB-SEM is the higher level of flexibility it offers to researchers. In other words, PLS-SEM has fewer issues with model identification and complexity. Other scholars concurring with this assertion includes Bentler and Huang (2014) as well as Dijkstra and Henseler (2015). Hence, based on the model identification problems faced with the use of CB-SEM, we

<sup>2</sup> For descriptive statistics and raw data, see: [https://1drv.ms/u/s!Apu7eaPP1VDdgZRBcGtZPcN\\_aXf3xg?e=zPYRW8](https://1drv.ms/u/s!Apu7eaPP1VDdgZRBcGtZPcN_aXf3xg?e=zPYRW8).

went with the PLS-SEM because it had the capacity to handle the issues we faced using the CB-SEM. These reasons explain our choice of PLS-SEM over the CB-SEM. However, we recommend that future studies should compare the PLS-SEM results of this study (or theirs) with those based on CB-SEM by securing larger sample sizes.

The component of urban form in this study is town center proximity–walk accessibility and other locational characteristics that reflect different types of land use at the neighborhood level—each stand for accessibility and land-use mix of a neighborhood—in addition to safety perception. This study initially considered 26 indicators in total. Later, due to lower factor loadings than the expected threshold (0.6), reliability and validity issues, the indicators were reduced to 16 (see Figure 5 and Table 2). Indicators with factor loadings of less than 0.6 were eliminated from the study. PLS-SEM is deemed to be a combination of confirmatory factor analysis (referring to the factor loadings) and regression analysis. The factor analysis component of the PLS-SEM was deemed to be sufficient. Similarly, the study conducted by Banerjee and Hine (2016) which sort to understand the influence of urban form on household automobile travel did not run a separate factor analysis aside from the one associated with PLS-SEM. This study included 4 first-order constructs, 1 second-order construct (eliminated in the final model), and 1 outcome construct. The first-order constructs included socio-demographics, town center proximity–walk accessibility, other locational characteristics, perception of public transport, and satisfaction from public transport. Travel behavior was evaluated with the frequency of automobile trips. This study employed a repeated indicator approach to model the causal relationship. The initial stage of the modelling process involved the estimation of the latent variable scores (LVs) through the iterative process. This stage ensured that the model satisfied all the statistical requirements for the model to be deemed acceptable. This was where the PLS algorithm was computed. The subsequent stage involved allowing the LVs as endogenous and exogenous variables into the constructs for the estimation process. (Henseler & Fassott, 2010, cited in Banerjee & Hine, 2016). This was done to reduce errors (endogenous constructs residual variance) to the barest minimum as proposed by Hair, Hult, Ringle, and Sarstedt (2014). The coefficient pathway helps to determine the direction of influence and at other times, it highlights conceptual and/or theoretical relationships that may exist. In particular, to determine which pathway is significant, a consistent bootstrapping was conducted with subsampling 10,000 times; this far exceeds the minimum recommended samplings of 5,000 (Hair et al., 2014). All other parameters were set at default.

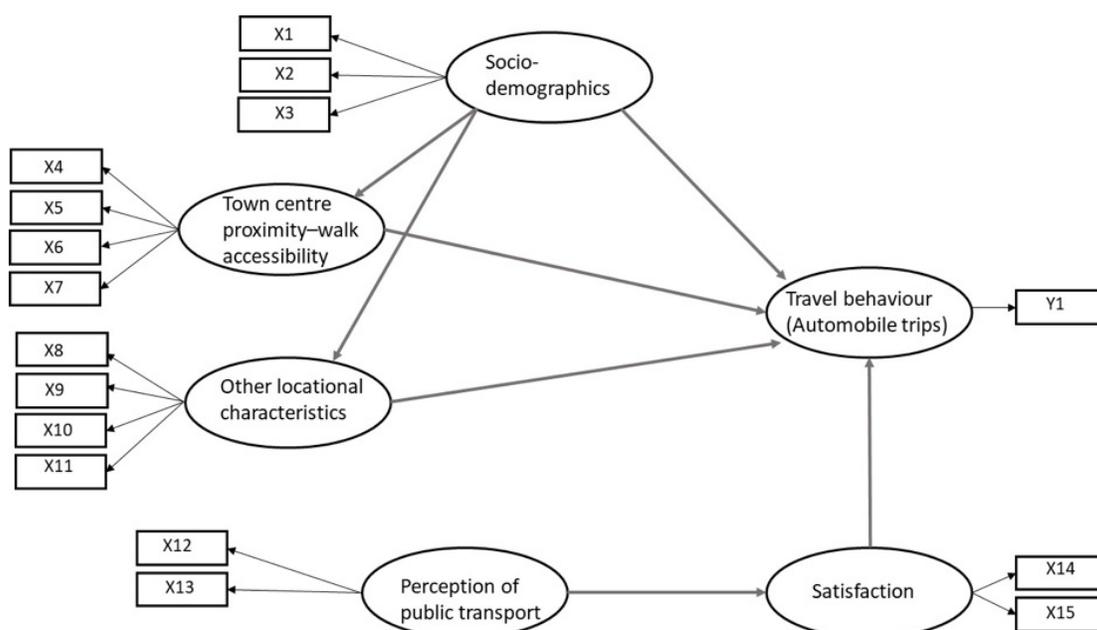


Figure 5. Research model

Note: It is conceptually sounder to specify the sociodemographic factor to be formative. However, in the travel behavior literature, there is a mix of reflective and formative factors for socio-demographics according to goodness-of-fit (Gim, 2019). [The fit is not the only standard for model evaluation, but arguably, model modification/re-specification according to fit indices is a norm even for “confirmatory” covariance-based SEM (Gim, 2018).] In this sense, socio-demographics were specified as a reflective factor because it led to a better fit. Meanwhile, different from the formative factor whose meaning depends entirely on the structure of its variables, an addition/removal/change of indicators for a reflective factor does not change its meaning since they are just phenotypes of the latent concept/factor (Gim, 2018).

## **4 Results and discussion'**

### **4.1 Model evaluation**

To check the goodness-of-fit of a PLS-SEM model, scholars have come up with a few indices including composite reliability (CR), convergent validity (CV), discriminant validity (DV), and standardized root mean squared residuals (SRMR). CR refers to the extent of consistency found within constructs. For constructs to satisfy this criterion, values need to be greater than 0.7 but in some instances, one might need to secure higher CR values to compensate for another criterion of content validity (Hair et al., 2014). To satisfy the CV requirement, the average variance explained (AVE) should be greater than 0.5 (Henseler, Ringle, & Sinkovics, 2009). Table 2 shows that all constructs satisfy the above criteria. The SRMR is often used to evaluate LV models as the main aim is to measure the extent of discrepancy between the observed model's covariance and the implied model covariance.

Even though there is less consensus on the criteria for evaluation, Hu and Bentler (1999) suggest that  $SRMR < 0.11$ . However, it should be noted that it depends on the sample size. A sample size of  $N < 250$ , a cut-off of between 0.06 to 0.08 may be appropriate. The model presented in this research chose a cut-off criterion of  $SRMR < 0.09$  and it falls within this evaluation criterion ( $SRMR = 0.07$ ). The last model-fit standard, the DV of the model was evaluated in accordance with Fornell and Larcker criterion. As a rule-of-thumb, the square root of the AVE must be greater than the construct's correlations (Fornell & Larcker, 1981). Table 3 shows that all constructs satisfy the Fornell and Larcker criterion.

PLS-SEM uses SRMR, NFI, and r-square to evaluate the goodness-of-fit and recently  $d_{ULS}$ ,  $d_G$ , and  $RMS_{theta}$ , as well as SRMR and NFI, were proposed. We referred to them. Nonetheless, several fit indices have not been developed comparable to those for CB-SEM such as RMSEA (Root Mean Square Error of Approximation), CFI (Comparative Fit Index), and SRMR.

**Table 2.** Factor loadings and its corresponding CR and AVE values for reflective constructs

Outer model (also called measurement model in CB-SEM)	Outer weights	Constructs	P-values of Constructs	CR	AVE
Employment status (X1)	0.939				
Income (X2)	0.633				
Age (X3)	0.729				
		Sociodemographic	0.019	0.723	0.521
Proximity to town center (X4)	0.841				
Minutes to walk to the nearest bus stop (X5)	0.801				
Minutes to walk to the nearest taxi rank (X6)	0.862				
Minutes to walk to the nearest grocery shop (X7)	0.794				
		Town Center Proximity– Walk Accessibility	0.001	0.818	0.573
Distance from residence to work (X8)	0.889				
Time taken to get to other shop (X9)	0.903				
Time taken to get to the nearest public facility (X10)	0.805				
Time taken to get to the nearest police station (X11)	0.683				
		Locational Characteristic	0.012	0.751	0.532
Reliability of transport to work (X12)	0.861				
Frequent transport schedule (X13)	0.857				
		Perception of Transport	0.019	0.805	0.601
Level of transit (X14)	0.782				
Bus frequency (X15)	0.756				
		Satisfaction	0.015	0.728	0.534

Note: for a satisfactory model, CR>0.70 and AVE>0.60

**Table 3.** Discriminant validity: Fornell and Larcker criterion

	Other Locational Characteristics	Town Center Proximity–Walk Accessibility	Perception of Transportation	Satisfaction	Sociodemographic	Automobile trips
Other Locational Characteristics (LC)	0.703					
Town Center Proximity–Walk Accessibility (NA)	0.538	0.755				
Perception of Transportation (PT)	-0.406	-0.285	0.579			
Satisfaction (SAT)	0.219	0.146	0.209	0.756		
Sociodemographic (SD)	0.226	0.173	-0.046	0.086	0.609	
Automobile trips (Y1)	-0.240	0.005	0.119	-0.167	0.356	0.598

Note: The square roots of the AVE are the highlighted values

#### 4.2 Path coefficients

First of all, the socio-demographic factor was found to be the most important factor in travel behavior as its standardized path coefficient (0.426) was the largest among the constructs (see Table 4). Its positive influence echoes the findings of previous studies including Best and Lanzendorf (2005) and Newbold, Scott, Spinney, Kanaroglou, and Paez (2005) to name a few. For example, Best and Lanzendorf (2005) argued that socio-demographics strongly influence automobile trip frequency. Newbold et al. (2005) also found that socio-demographics have a significant effect on the trip frequency and that older people are more likely to make fewer trips compared to younger people. In addition, a study by Cao et al. (2007) concluded that socio-demographics is key in explaining variations in travel behavior. It should be noted that this factor did not significantly affect town center proximity–walk accessibility and other locational characteristics, the two components of urban form. These results may suggest that there exists residential self-selection that was not controlled for in this study, similar to previous studies (Ewing et al., 2014; Gehrke & Clifton, 2017).

Moreover, the study also revealed that both constructs of urban form (town center proximity–walk accessibility and other locational characteristics) significantly affect travel behavior. First, regarding town center proximity–walk accessibility, its positive effect (0.172) implies that as with poor proximity to transit facilities, people are less likely to use public transit and instead, they will be forced to use automobiles thereby increasing automobile trip frequency (refer to Table 4). This makes proximity to transit a key variable in the transportation–travel behavior relationship. This result is consistent with the work of Ding et al. (2017), which showed that when people live closer to transit facilities, they are more likely to use public transit compared to automobiles and the reverse is also true when transit facilities are far away; in this case (as it is in the case of Accra), automobile usage by default is encouraged.

Also, locational characteristics that served as a proxy for neighborhood walkability the area possesses were found to be significant as with previous studies (Zhang, 2004). However, an added twist to this result is that because transit facilities were not closer, people tended to use automobiles to get to their destinations as compared to using transit. Another reason that can be advanced to explain such an occurrence is poor neighborhood designs and a lack of adequate connectivity among activity locations. Zhang

(2004) argued that higher connectivity among neighborhoods coupled with adequate cycling and walking infrastructure would result in less use of cars, thus, resulting in lower automobile trips. The reverse is true in the case of Accra as it lacks adequate pedestrian/cycling infrastructure and the road network can be said to be radial. This presupposes that a combination of closeness to transit facilities and reliable public transit services coupled with higher levels of mixed land use in addition to better street design, which includes convenient cycling and walking paths, will consequently reduce automobile trips; this will ultimately lead to more use of public transit and non-motorized modes. This argument is in line with the findings of Krizek (2003) and Næss & Jensen (2004) among others.

**Table 4.** Direct, indirect effect, total effects, and p-values

Construct	Construct	Direct effect	Indirect effect	Total effects	f <sup>2</sup>	R <sup>2</sup>	Adj. R <sup>2</sup>	P- values
Sociodemo-graphic	→ Automobile trips	0.426	-0.071	0.355	0.32	0.471	0.452	0.000
Sociodemo-graphic	→ Town center proximity-walk accessibility	0.174	0.000	.0174	0.15	0.177	0.154	0.000
Sociodemo-graphic	→ Other locational characteristics	0.288	0.000	0.228	0.23	0.299	0.241	0.000
Town center proximity-walk accessibility	→ Automobile trips	0.172	-0.018	0.154	0.18	0.22	0.198	0.000
Other locational characteristics	→ Automobile trips	-0.361	-0.079	-0.44	0.21	0.266	0.215	0.000
Perception of Transportation	→ Satisfaction	0.355	0.007	0.362	0.11	0.124	0.104	0.000
Satisfaction	→ Automobile trips	-0.166	0.022	-0.144	0.09	0.099	0.073	0.000

Lastly, in Accra, people's perception of public transport, as well as their satisfaction from its usage, appears to have the potential to reinforce its usage or to make people shift from automobiles to alternative modes. Perception of public transport was found to have an indirect relationship with automobile trip frequency by directly increasing the satisfaction level. Indeed, people's perception of activities may affect the satisfaction derived from it and hence, may differentiate the likelihood of occurrence. The coefficient of the path between satisfaction and travel behavior was significant and negative (-0.166), indicating that when people are satisfied with services provided by public transit, it is likely that they will reduce automobile trips possibly because of a shift to other alternatives, particularly public transit. Similarly, De Vos and Witlox (2017) argued that satisfaction derived from travel is highly likely to affect the choice of a particular travel mode. Notably, other studies (Mouwens, 2015; van Lierop, Badami, & El-Genaidy, 2017) found that customers who frequently use transit services are more likely to be satisfied with the service. They further showed that reliability, frequency, and comfort are among the few that influence people's perception of public transit, which consequently leads to an increase, decrease or a shift from it.

## 5 Conclusion

The main focus of this paper was to confirm whether or not travel determinants that have been identified in the literature have significant effects on automobile travel behavior in the case of Ghana. Travel behavior in the analysis of this article is restricted to automobile trip frequency even though various scholars have used it to describe mode choice, trip frequency and other variables found within the dis-

course. Travel determinants considered in this study were socio-demographics and urban form (town center proximity–walk accessibility and other locational characteristics). As its unique feature, this paper also included perception of and satisfaction from public transport in the land use-travel behavior relationship, which was inspired by the concept of SWB. In order to understand the complex relationship between these factors, the PLS-SEM approach was employed.

The major findings of this study were that socio-demographic and urban form construct significantly affected travel behavior, which was expressed with automobile trip frequency. Also, perception of and satisfaction from public transport had negative effects on automobile trip frequency. This implies that improvement in public transport will reduce automobile dependence in Accra. People may switch from the automobile to public transport if the latter becomes more reliable in terms of service frequency, punctuality, and convenience. Better perception of public transport can also be realized when transit facilities are closer to people's residences. Therefore, Ghanaian policymakers are recommended to strive to incorporate the transit-oriented development concept in their spatial planning process. Furthermore, shortening distances between different land uses as well as providing cycling infrastructure between such land uses would substantially increase non-motorized travel and reduce automobile dependence. This will only be possible if the current urban sprawl phenomenon is "arrested" and shifted in favor of a more compact urban form.

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