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# PROMOTING SUSTAINABLE TRAVEL CHOICES: A MODE SHIFT FROM CAR DEPENDENCY TRAVEL IN NEW CAIRO, EGYPT: INSIGHTS FROM STATED PREFERENCE

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**Abstract**

The selection of a travel mode is a complex process influenced by various factors, including habits, lifestyle, psychological elements, and the built environment. Interact with these elements, and their influence varies based on contextual factors such as urban settings, cultural nuances, and travel patterns. The mode shift from car emerges as a compelling focus, necessitating a comprehensive exploration of the influential factors that underlie the change in travel preferences. In rapidly urbanizing areas like New Cairo, the challenges posed by functional zoning and the lack of pedestrian-friendly infrastructure present obstacles to advancing sustainable mobility. This raises a fundamental question: Are residents willing to transition to more sustainable travel choices if viable alternatives and friendly environment are provided, and what variables can influence a shift away from car dependency? To address this question effectively, a hypothetical scenario becomes indispensable. This study delves into these influential factors, utilizing a binary logistic regression analysis based on data from a comprehensive stated preference survey integrated with GIS. The survey captures resident preferences across demographic characteristics, travel patterns, and the built environment, while the logistic regression method provides a nuanced understanding of how variables interact to influence travel mode shifts. The study's conclusion underscores the significance of density, employment status, car captivity, and work location. The complex nature of these factors underscores the critical necessity to incorporate them into urban planning initiatives. This entails the development of comprehensible frameworks that effectively facilitate the transition towards sustainable travel choices.

**Keywords:** Travel Choices Preferences, Mode Shift, Car Dependency, Stated Preference, New Cairo, Egypt.

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## INTRODUCTION

The decision-making process involved in selecting a travel mode is a complex and multifaceted phenomenon influenced by a myriad of interconnected factors. Habits, lifestyle choices, psychological elements, and considerations of the built environment all play crucial roles in shaping individual preferences for transportation modes (Havlícková, 2020; Scheiner, 2007; Sutomo et al., 2003; Balcombe et al., 2003; Olsson et al., 2003). This intricate interplay of elements exhibits variations based on contextual factors such as urban settings, cultural nuances, family compositions, and diverse travel patterns.

The existing body of literature underscores the significance of understanding these factors, emphasizing the need for a comprehensive exploration of the factors that influence changes in travel mode preferences, especially in rapidly urbanizing areas like New Cairo. As urban environments evolve, challenges related to functional zoning and the lack of pedestrian-friendly infrastructure pose obstacles to the advancement of sustainable mobility. The shift away from car dependency becomes a crucial focus, prompting the question of whether residents are willing to transition to more sustainable travel choices if provided with viable alternatives and a friendly environment.

This study addresses this fundamental question by delving into the influential factors affecting the change in travel mode preferences from car to other sustainable choices in New Cairo, Egypt. In particular, it focuses on the challenges posed by the built environment, demographic characteristics, and travel patterns specific to this region. To effectively explore these factors, a comprehensive stated preference survey integrated with GIS is conducted. This survey captures resident preferences across various dimensions, including demographics, travel patterns, and built environment characteristics. Building on the insights from the literature, the study utilizes binary logistic regression analysis to discern the nuanced interactions of these variables and their impact on travel mode shifts. The study aims to contribute to the literature by addressing the gap in understanding the causal factors behind mode shift, particularly in the MENA region.

The subsequent sections of this paper will delve into the literature that informs the study, the unique factors influencing mode choice in the MENA region, the methodology employed in the survey, and the key findings that shed light on the influential factors for mode shift in New Cairo. By examining these elements, the study aims to provide valuable insights for urban planning initiatives that seek to promote sustainable travel choices in rapidly evolving urban environments.

### 1. Background:

The decision-making process for selecting a travel mode is intricate and influenced by a myriad of factors. Habits, lifestyle, psychological elements, and considerations of the built environment all play pivotal roles in shaping preferences. Havlícková (2020) underscores the significance of habit, portraying it as an automatic and deeply ingrained aspect of travel mode decisions. Moreover, Scheiner (2007) acknowledges that lifestyle plays a role in this decision-making process, although its impact is somewhat less compared to life situations and

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significant life events such as the birth of a child (McCarthy, 2017). The exploration of psychological factors by Sutomo (2003), Balcombe (2003), and Olsson (2003) further highlights the intricate interplay of habit, lifestyle, and psychological and environmental elements in shaping travel mode preferences, encompassing considerations related to security and convenience. These factors exhibit variability based on specific contextual factors such as urban settings, cultural nuances, family compositions, and diverse types of journeys.

The multifaceted decision-making process also involves considerations of the travel environment, encompassing the quality and accessibility of public transportation, the presence of pedestrian-friendly infrastructure, and overall convenience, all of which significantly shape preferences. Economic factors, such as fuel costs and public transportation fares, further contribute to the decision-making matrix. Social and demographic factors introduce additional layers of influence, considering variables like age, gender, income, and family composition.

Numerous studies on sustainable travel mode choices highlight a multifaceted approach to influencing individual travel preferences. Personalization is key, as shown by Sochor (2015) through the effectiveness of personalized transportation packages and Lind (2015) through the influence of personal norms and situational factors, especially in urban settings with sustainable public transport. Schneider (2013) broadens this by identifying factors like awareness, safety, convenience, cost, enjoyment, and habit in routine travel choices.

The role of infrastructure is also crucial, with advancements in energy-efficient vehicles and cycling infrastructure significantly impacting travel choices, as well as enhanced walking and biking networks promoting active transportation. Soft policy measures, such as those developed by Esztergár-Kiss (2021) utilizing a route planner with considerations like travel time, cost, and environmental impact, offer cost-effective alternatives to engineering solutions. Finally, socio-demographic and economic factors, as discussed by Quarmby (1967) and Wójcik (2019), including travel time differences, cost differences, and access to cars, are significant determinants of travel mode choice. These studies collectively suggest that sustainable travel choices are influenced by a complex interplay of individual preferences, infrastructure, policy measures, and socio-demographic factors, underscoring the need for comprehensive and personalized strategies in promoting sustainable transportation systems.

The MENA region shows unique determinants for travel mode choices distinct from Western societies. Key barriers in the MENA region include long walking distances, inadequate biking infrastructure, social and cultural pressures against biking, and a general preference for cars over public transportation. Comfort and convenience are highlighted as major reasons for favoring cars over public transit in these regions (Masoumi, 2019).

This highlights the context-specific nature of travel mode decisions, pointing to significant differences in perceived and actual obstacles to sustainable mobility and motivations for car usage between the MENA region and Western societies. A notable gap in the existing literature is the limited understanding of the causal factors behind mode preference in the MENA region (Masoumi, 2019). Addressing this gap is essential for effective transport planning and decision-making aimed at promoting more sustainable and active transportation choices.

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Introducing novel transportation options incurs significant costs, and gauging travelers' acceptance of these measures in advance proves challenging. Impact assessments heavily rely on surveys, particularly employing stated choice experiments to gather data on hypothetical scenarios. Choice models are subsequently utilized to predict the adoption of new travel options. Broadly speaking, there are two primary data sources for estimating mode and route choice models (Khan, 2007; Delmelle & Delmelle, 2012).

The first entails revealed preference (RP) data, recording the actual behavior of travelers. The second involves stated preference (SP) data, where respondents make choices among various scenarios during a survey. Both approaches come with their respective advantages and disadvantages (Beck et al., 2016). SP data offers the flexibility of including hypothetical scenarios and allows control over survey design. Conversely, RP data reflects real behavior and avoids the hypothetical biases often encountered in SP data, where individuals must respond to questions about hypothetical behavior in an unfamiliar setting.

In conclusion, the exploration of travel mode choice is a complex and multifaceted domain that not only influenced by personal preferences and habits but also significantly shaped by external factors such as the availability and quality of transportation infrastructure, economic considerations, and social and demographic variables. The study reveals gaps, particularly in understanding the causal factors that can affect changes in travel preferences, especially in diverse regions like the MENA as opposed to Western societies.

Furthermore, the methodologies used to study these preferences, such as revealed and stated preference data, each offer unique insights but also pose their own set of challenges. Addressing these gaps and refining these methodologies are crucial for developing more effective and sustainable transportation policies and systems that are responsive to the varied and dynamic needs of different populations. The collective insights from these studies and methodologies underscore the need for a holistic and nuanced approach to understanding and influencing travel mode choices in the pursuit of more sustainable and efficient transportation systems.

### 1.1 The Case Study, New Cairo, Egypt:

The Egyptian government embraced the concept of new urban communities (NUCs) as a strategic response to the escalating urbanization across the country and as a remedy for longstanding challenges. The swift migration of individuals from rural areas to more developed regions led to what is termed “over-urbanization” in certain cities (Nagi, 1974; Chaichian, 1988). Cairo, being the capital and renowned for its employment opportunities and services, faced the imperative of urban expansion due to a continuous population surge (Abdel-Kader and Ettouney, 2013).

In the early 1980s, the government initiated the first generation of seven new cities, each designed, according to national policy, to possess an autonomous economic base, industrial prowess, government housing projects, and subsidized land for investment and expansion (Tadamun, 2015). Subsequently, in 1986, the second generation comprising nine satellite towns was introduced in proximity to the initial generation (Hegazy and Moustafa, 2013).

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**Figure 1: Location of New Cairo (studied Area) related to Cairo the Capital, Egypt**

The establishment of New Cairo began in the 90's through a presidential decree, with a primary aim of easing congestion in downtown Cairo and expanding the capital eastward. Encompassing an expansive area of about 500 km2, New Cairo was envisioned to house nearly 5,000,000 residents. However, as of 2020, the actual population is approximately 300,000, as reported by the New Cairo Authority. Despite its goal of fostering inclusive urbanism, the development of New Cairo resulted in social exclusion, notably attributed to the emergence of walled gated communities and urban fragmentation.

Illustrated in Figure 2, it is evident from the land use distribution that residential areas and gated compounds extensively dominate the landscape. A distinct separation between residential and commercial zones is observable, resulting in a ratio favoring residential areas over commercial ones. This highlights that the planning of New Cairo leans more towards functional zoning rather than embracing a mixed-use approach.

Analysing the frequency of land uses within the 600m catchment area of participants, the distribution reveals that 86% was residential, 8% commercial, 3% educational, 2% recreational, and 1% health land uses. This distribution underscores the predominant emphasis on residential spaces in the vicinity, contributing to the functional zoning character of New Cairo.

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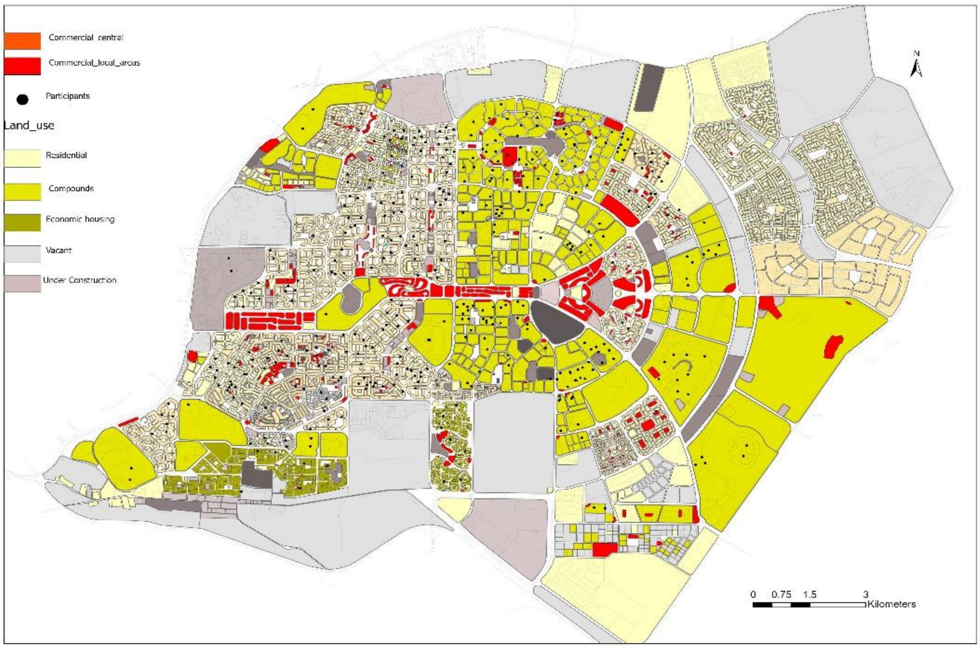


**Figure 2: Land use distribution (Source: author)**

## 2. Method and Sample Selection:

The survey employs an integrated methodology comprising two main phases: a quantitative section supplemented by a qualitative attitudinal section. This approach proves powerful in comprehending nuanced choices, providing insights and justifications for the quantitative section, which includes considerations of built environment characteristics, demographics, socio-economic factors, and selected travel modes (Kitamura et al., 1997; Clifton & Handy, 2001). Additionally, the survey incorporates an experimental section delving into the stated preferences of travelers, a discussion of which will follow in the paper. Statements within the survey vary, with some calibrated on a Likert-type scale, while others prompt participants to select the most suitable answer or add their own under the “other” category.

All respondents were geo-referenced, leveraging GIS modeling of the study area. This geospatial approach enables the integration of variables derived from the built environment, such as density, the ratio between residential and commercial areas within a participant's 600m catchment area, distance to the nearest commercial shop (grocery store), and the availability of other amenities like recreational, educational, and religious facilities. These variables, coupled with demographic information and travel patterns, will be synthesized in a binary logistic regression model. The purpose of this model is to scrutinize the significant variables influencing the decision to change travel modes. The study applied a binary logistic regression model to analyze the data and identify the significant or marginally significant variables that influenced the change decision.

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To ensure a robust 95% confidence level with a 5% margin of error in the survey results, Cochran's sample size formula was used, which recommended a representative sample of 384 respondents. The online survey remained open until it reached its target of 400 participants, at that point it was closed to facilitate result analysis due to the specified time constraints of the research.

**2.1 Participants' Properties:**

New Cairo settlement, has a distinct appeal for specific socio-economic segments, particularly those belonging to the higher to upper-middle social class, as depicted in Table 1. This socio-economic profile of the participants manifests in various other variables, such as patterns of car ownership, the predominant type of residential blocks (mostly gated compounds), and travel intensity. As noted by (Dargay & Clark, 2012), there exists a strong correlation between income levels and travel distances, further underscoring the influence of socio-economic factors on various aspects of life in New Cairo. Additionally, the high travel intensities observed in the area reflect the considerable distances between residential locations and daily services. This phenomenon can be attributed to the functional zoning of land use and the low population densities in New Cairo, factors that contribute to the extended travel distances residents need to cover for their daily activities.

A balanced distribution is observed in the percentage of females to males within the sample. Furthermore, the age distribution spans from 25 to 60 years old, encompassing individuals typically in the working age bracket. This specific age group is recognized for its engagement in regular employment, suggesting mandatory work trips and household-related travel. The nature of their activities generates a relatively fixed pattern of trips, making it particularly pertinent to focus on the habitual use of specific travel modes in the study of transportation behaviours (Hahn et al., 2016).

Participants were tasked with evaluating the walkability of their neighbourhood and gauging their perceptions. This assessment employed a 5-point Likert scale that encompassed three key aspects: the encouragement to use active transportation modes, the proximity of shops and services within walking distance, and the perceived level of safety. A substantial majority of 53% identified the neighbourhood as moderately walkable, aligning with the characteristics of the studied area. This observation is consistent with the car-centric road hierarchy, where pedestrian-friendliness is limited due to wide streets and a lack of secure crossing zones. Additionally, the absence of shaded areas contributes to a less pedestrian-friendly environment. The concentration of services further emphasizes their accessibility by car rather than on foot.

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**Table 1: Socio-Demographic distribution of the sample**

| | | Count | Column N % |
|---|---|---|---|
| Age | 18 to 24 years old | 22 | 5.7% |
| | 25 to 40 years old | 186 | 48.2% |
| | 40 to 60 years old | 140 | 36.3% |
| | More than 60 | 38 | 9.8% |
| Gender | Female | 220 | 57.0% |
| | Male | 166 | 43.0% |
| Economic_level | Below moderate | 4 | 1.0% |
| | Moderate | 164 | 42.5% |
| | High | 218 | 56.5% |
| Residential_block | Type B | 33 | 8.5% |
| | Type A | 170 | 44.0% |
| | Rehab | 51 | 13.2% |
| | Compounds | 132 | 34.2% |
| Walkability | Low Walkability | 77 | 19.9% |
| | Moderate Walkability | 206 | 53.4% |
| | High Walkability | 103 | 26.7% |
| Travel_Intensity | Low mobile users | 41 | 10.6% |
| | Moderate mobile users | 146 | 37.8% |
| | High mobile users | 199 | 51.6% |
| Commuter_Description | Under responsibility | 11 | 2.8% |
| | Companions | 47 | 12.2% |
| | Drop off family | 125 | 32.4% |
| | Lonely commuter | 203 | 52.6% |

### 2.2 The Stated-of-revealed Preference:

In the realm of travel surveys, the widespread adoption of stated preference (SP) methods is evident in efforts to comprehend shifts in people's behaviour when new travel options are introduced (Stopher and Jones, 2003). These travel alternatives are typically presented to survey participants as hypothetical scenarios, prompting them to articulate their preferences while considering their current mode of travel and potential alternatives (Khan et al., 2007). The value of employing this method in transportation lies in its ability to yield reliable estimates of the relative importance of choice attributes and its flexibility to incorporate travel modes not currently available in the market (Beck et al., 2016).

In the specific context of “New Cairo, Egypt” this approach proves particularly apt. The region's low-density development nature results in a limited diversity of travel options, making it challenging to accurately trace travel choices. This limitation suggests that conventional travel surveys may not adequately reflect preferences and inclinations toward other options.

However, a drawback of relying on stated preferences for decision-making is that they may not accurately predict actual behavior. The general literature comparing stated and revealed preferences (RP) has found that individuals tend to overstate their valuation of a particular

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good, service or outcome, which can lead to misleading estimates of relative value or hypothetical bias (Fifer al., 2014, Beck et al., 2016). As highlighted by Penn and Hu (2019) in their discussion on hypothetical bias, the "cheap talk" method serves as a means to motivate participants to candidly articulate their genuine preferences. This technique involves a transparent approach wherein respondents are explicitly apprised of the hypothetical bias in the study. Moreover, Participants receive clear information about the research's significance before they embark on the decision-making task. This upfront disclosure fosters a more sincere and accurate expression of their preferences during the choice task. This proactive disclosure seeks to mitigate any potential reluctance or bias arising from participants when providing their preferences, fostering a more accurate and genuine representation of their true attitudes and choices. This method is proved by the work of Cummings and Taylor (1999), who discovered that the willingness to pay using hypothetical scenarios using Cheap Talk (CT) showed no significant difference compared to actual scenarios across various goods. Subsequently, CT has become a standard practice in the design of surveys and elicitation methods for stated preferences.

Moreover, in the presented study, the study deployed a pictorial form with caption elaboration. The caption elaboration presents the cons and pros of each travel mode choice to minimize any overestimation or inaccurate expectations (see Figure 4).

**2.3 Survey Design:**

The survey relied on four main sections: the first section focused on collecting demographic information, including details such as age, gender, economic level, and employment status. The following section centered on exploring travel behaviors, and patterns. The third segment extensively investigated the factors contributing to the perpetuation of car dependency. This included an attitudinal section that probed into the reasons behind the reliance on cars and delved into the motivations that might drive participants to opt for alternative, sustainable modes of travel. Lastly, the survey concluded with the stated preference experiment (hypothetical scenario) that investigated the feasibility of changing the revealed travel behaviour to other sustainable choices.

The survey outcome proposed categorizing participants into three distinct groups based on their responses to a screening question “What is your primary travel mode?”. The first group comprises individuals classified as “car reliant” or those who drive cars which presents 84%. The second group includes “car passengers” who utilize ride-hailing apps or taxis which presents 14%. The third group consists of public transportation users. However, due to their limited representation, accounting for only 2% of the total sample, and considering the study's nature, results pertaining to the third group were omitted (see Figure 3).

Within the “car-reliant” group, further classification was carried out. This subgroup was divided into two categories: one comprising individuals who asserted that they cannot substitute their cars which constituted 15%, and the other consisting of those who expressed the possibility of substituting their cars, including responses such as “maybe” or “yes, sure, I can substitute my car” which constituted 85% of the sample. Consequently, the study proceeded

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to develop three distinct stated preference experiments tailored to each of the identified groups: the “car passenger” group, the “car non-substitutes”, and the “car substitutes”. Each group participated in two hypothetical scenarios, one focusing on long trips exceeding 15 minutes of driving, and the other centered on shorter trips lasting less than 10 minutes of driving. These experiments were carefully crafted to capture the unique preferences, attitudes, and decision-making processes characteristic of each subgroup within the larger “car-reliant” category.

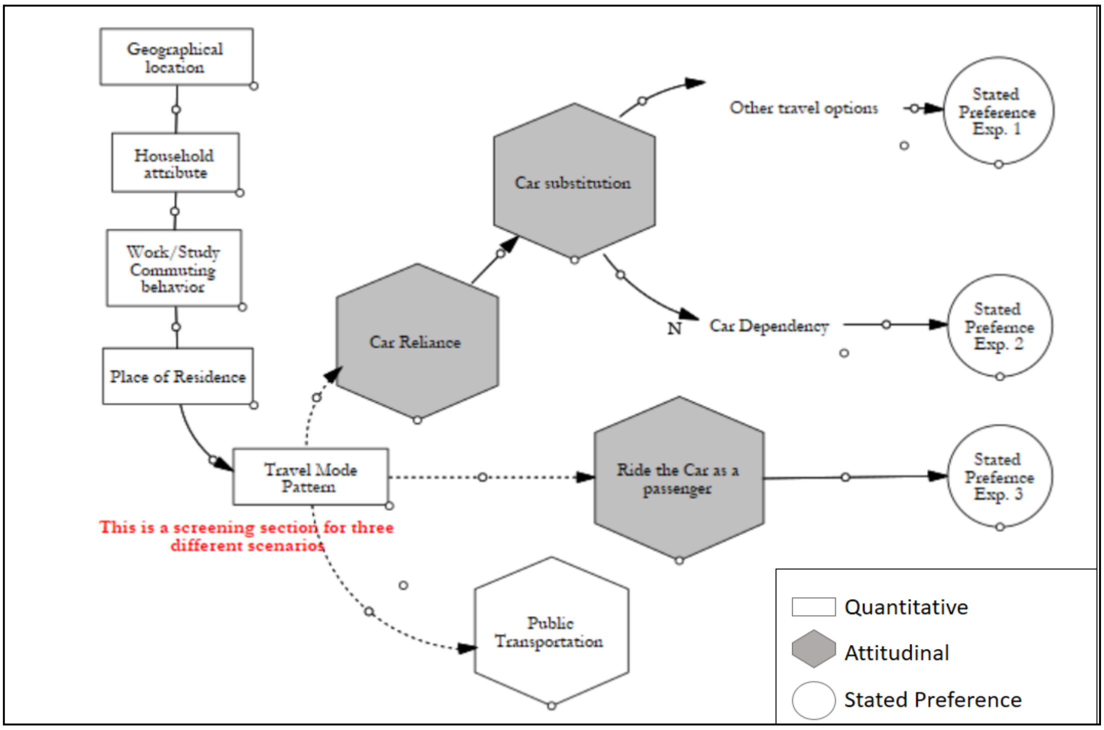


**Figure 3: The survey design model (source: the author)**

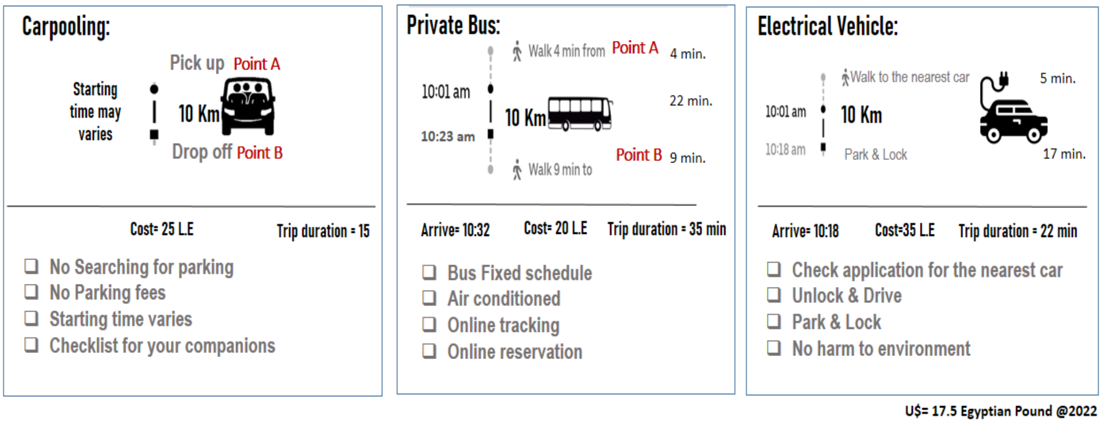


**Figure 4: Hypothetical Scenario for Car dependent users (long trip), (source: the author)**

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As seen in Figure 4, this scenario represents the hypothetical scenarios for individuals classified as “car non-substitutes”, identified through their revealed preference of not replacing their cars (Experiment number 2, long trip, as illustrated in Figure 3). Respondents were prompted to consider their choices if faced with both a short trip and a long-distance trip, evaluating which travel modes they would rely on. To mitigate potential overvaluation or unfamiliarity with the options, a set of comparison criteria was presented, encompassing factors such as trip duration, cost, parking availability, and the starting time of the trip.

## 3. RESULTS AND DISCUSSION

### 3.1 Degree of Change:

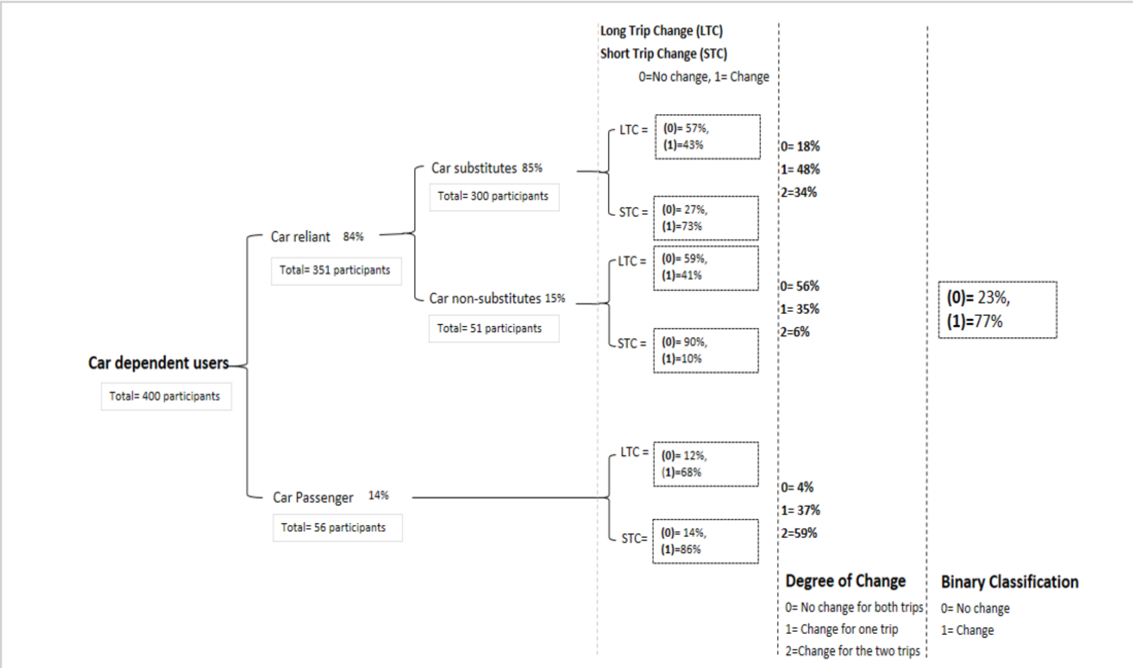


**Figure 5: The results of the experimental section to binary classification**

The hypothetical scenario yielded a variable termed “degree of change”, reflecting participants' responses in the experimental phase regarding their willingness to shift from their primary mode of transportation, the “car”, to alternatives. As illustrated in Figure 5, a positive change denotes a preference for a mode different from their reliance on cars. Notably, for short trips, there was a greater inclination towards positive change, surpassing the tendency observed for long trips. This trend was consistent across most groups, except for “car non-substitutes”, who exhibited a higher likelihood of not changing, aligning with their earlier indications of reluctance to substitute their cars. This finding is in harmony with participants' prior responses regarding their openness to car substitution. In this context, Kuhnimhof et al. (2006) noted that individuals who drive cars are typically characterized as being predominantly mono-modal. Nevertheless, even among “car non-substitutes”, there remains a noteworthy percentage

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showing a positive change, particularly evident in the context of long trips. This suggests a nuanced perspective within this group, where a fair proportion still demonstrated a willingness to consider alternative travel modes, even for more extended journeys. The majority of this group opted for the "Monorail" as their preferred alternative for long trips, those exceeding 30 km, as outlined in the experiment. This inclination likely mirrors their careful consideration of factors such as time efficiency, service quality and petrol costs associated with this particular mode of transportation.

**Table 2: Demographic Characteristics of Participants across (Change to No change variable), (n = 389)**

| | | Change_NoChange | | | | | |
|---|---|---|---|---|---|---|---|
| | | No Change | | | Change | | |
| | | Count | Table N % | Row Total N % | Count | Table N % | Row Total N % |
| Age | 18 to 24 years old | 5 | 1.3% | 22.7% | 17 | 4.4% | 77.3% |
| | 25 to 40 years old | 38 | 9.8% | 20.4% | 148 | 38.3% | 79.6% |
| | 40 to 60 years old | 35 | 9.1% | 25.0% | 105 | 27.2% | 75.0% |
| | More than 60 | 12 | 3.1% | 31.6% | 26 | 6.7% | 68.4% |
| Gender | Female | 46 | 11.9% | 20.9% | 174 | 45.1% | 79.1% |
| | Male | 44 | 11.4% | 26.5% | 122 | 31.6% | 73.5% |
| Economic_level | Below moderate | 0 | 0.0% | 0.0% | 4 | 1.0% | 100.0% |
| | Moderate | 35 | 9.1% | 21.3% | 129 | 33.4% | 78.7% |
| | High | 55 | 14.2% | 25.2% | 163 | 42.2% | 74.8% |
| Walkability | Low Walkability | 20 | 5.2% | 26.0% | 57 | 14.8% | 74.0% |
| | Moderate Walkability | 49 | 12.7% | 23.8% | 157 | 40.7% | 76.2% |
| | High Walkability | 21 | 5.4% | 20.4% | 82 | 21.2% | 79.6% |
| Gated | Not gated | 53 | 13.7% | 21.9% | 189 | 49.0% | 78.1% |
| | Gated | 37 | 9.6% | 25.7% | 107 | 27.7% | 74.3% |
| Commuter_Description | Under responsibility | 5 | 1.3% | 45.5% | 6 | 1.6% | 54.5% |
| | Companions | 10 | 2.6% | 21.3% | 37 | 9.6% | 78.7% |
| | Drop off family | 35 | 9.1% | 28.0% | 90 | 23.3% | 72.0% |
| | Lonely commuter | 40 | 10.4% | 19.7% | 163 | 42.2% | 80.3% |
| Travel_Intensity | Low mobile users | 13 | 3.4% | 31.7% | 28 | 7.3% | 68.3% |
| | Moderate mobile users | 37 | 9.6% | 25.3% | 109 | 28.2% | 74.7% |
| | High mobile users | 40 | 10.4% | 20.1% | 159 | 41.2% | 79.9% |
| Car_captivity_3 | Not car users | 6 | 1.6% | 17.1% | 29 | 7.5% | 82.9% |
| | Car captive | 55 | 14.2% | 29.6% | 131 | 33.9% | 70.4% |
| | Car relcutant | 10 | 2.6% | 15.9% | 53 | 13.7% | 84.1% |
| | Car inclined | 19 | 4.9% | 18.6% | 83 | 21.5% | 81.4% |
| Shop_Grocery | Don't perform | 1 | 0.3% | 8.3% | 11 | 2.8% | 91.7% |
| | Accessible by multi-modes | 0 | 0.0% | 0.0% | 1 | 0.3% | 100.0% |
| | Have Parking area | 20 | 5.2% | 29.9% | 47 | 12.2% | 70.1% |
| | Availability of mixed-use area | 3 | 0.8% | 15.0% | 17 | 4.4% | 85.0% |
| | Value for money | 25 | 6.5% | 25.0% | 75 | 19.4% | 75.0% |
| | Review of the place | 8 | 2.1% | 21.1% | 30 | 7.8% | 78.9% |
| | Proximity to home | 33 | 8.5% | 22.3% | 115 | 29.8% | 77.7% |
| Reach_supermarket | Walk | 7 | 1.8% | 15.2% | 39 | 10.1% | 84.8% |
| | Drive to it | 75 | 19.4% | 24.8% | 228 | 59.1% | 75.2% |
| | Delivery | 8 | 2.1% | 21.6% | 29 | 7.5% | 78.4% |
| Primary_mode | PT/Walking | 0 | 0.0% | 0.0% | 0 | 0.0% | 0.0% |
| | Car passenger/taxi | 6 | 1.6% | 17.1% | 29 | 7.5% | 82.9% |
| | Car | 84 | 21.8% | 23.9% | 267 | 69.2% | 76.1% |

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### 3.2 Binary Logistic Regression Model

**Table 3: Number of Questionnaires' results included in the Logistic Regression Analysis**

| Cases | | N | Percent |
|---|---|---|---|
| Selected Cases | Included in Analysis | 386 | 99.2 |
| | Missing Cases | 3 | .8 |
| | Total | 389 | 100.0 |
| Unselected Cases | | 0 | .0 |
| Total | | 389 | 100.0 |

Table 3, shows that out of a total 389 Questionnaires (cases) included in the Logistic Regression analysis, 386 questionnaires were included in the analysis and three were considered missing.

**Table 4: The Omnibus Test of Model Coefficients**

| Step No | | Chi-square | df | Sig. |
|---|---|---|---|---|
| Step 1 | Step | 37.617 | 4 | .000 |
| | Block | 37.617 | 4 | .000 |
| | Model | 37.617 | 4 | .000 |
| Step 2 | Step | 10.603 | 1 | .001 |
| | Block | 48.220 | 5 | .000 |
| | Model | 48.220 | 5 | .000 |
| Step 3 | Step | 33.513 | 15 | .004 |
| | Block | 81.733 | 20 | .000 |
| | Model | 81.733 | 20 | .000 |
| Step 4 | Step | .453 | 3 | .929 |
| | Block | 82.186 | 23 | .000 |
| | Model | 82.186 | 23 | .000 |

Table 4, shows the Omnibus Test of Model Coefficients (the overall test of the logistic regression model). The step column represents the forward selection step number, which indicates that the best model was obtained after the fourth step with a Chi-square equal to 0.453 and p-value < 0.01.

**Table 5: Model Coefficient of Determination**

| Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|
| 1 | 381.631 | .093 | .140 |
| 2 | 371.028 | .117 | .177 |
| 3 | 337.515 | .191 | .288 |
| 4 | 337.062 | .192 | .289 |

Table 5, shows the -2 Log-likelihood, and Cox & Snell as well as the Nagelkerke *R2* values, where the latter is a modification of the Cox & Snell *R2*, which cannot achieve a value of 1. The -2 Log likelihood is mainly to compare nested models, where the lowest -2 Log likelihood value represents the best model. The forward selection algorithm terminated at the fourth step, which represents the lowest -2Log likelihood value (337.062) associated with the highest Nagelkerke *R2* value (0.289).

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**Table 6: Hosmer and Lemeshow Test**

| Step | Chi-square | df | Sig. |
|---|---|---|---|
| 1 | .000 | 2 | 1.000 |
| 2 | 1.614 | 4 | .806 |
| 3 | 5.934 | 7 | .547 |
| 4 | 5.952 | 8 | .653 |

Table 6, represents the results of the Hosmer-Lemeshow test, which examines the null hypothesis that predictions made by the model fit perfectly with observed group memberships. A non-significant chi-square (5.952 with p-value 0.653 >> 0.05) indicates that the data fit the model very well.

**Table 7: Classification Table**

<table>
<tr><th colspan="3" rowspan="3">Observed</th><th colspan="3">Predicted</th></tr>
<tr><th colspan="2">Change_ No Change</th><th rowspan="2">Percentage Correct</th></tr>
<tr><th>No Change</th><th>Change</th></tr>
<tr><td rowspan="3">Step 1</td><td rowspan="2">Change_NoChange</td><td>No Change</td><td>19</td><td>71</td><td>21.1</td></tr>
<tr><td>Change</td><td>8</td><td>288</td><td>97.3</td></tr>
<tr><td colspan="2">Overall Percentage</td><td></td><td></td><td>79.5</td></tr>
<tr><td rowspan="3">Step 2</td><td rowspan="2">Change_NoChange</td><td>No Change</td><td>19</td><td>71</td><td>21.1</td></tr>
<tr><td>Change</td><td>8</td><td>288</td><td>97.3</td></tr>
<tr><td colspan="2">Overall Percentage</td><td></td><td></td><td>79.5</td></tr>
<tr><td rowspan="3">Step 3</td><td rowspan="2">Change_NoChange</td><td>No Change</td><td>26</td><td>64</td><td>28.9</td></tr>
<tr><td>Change</td><td>13</td><td>283</td><td>95.6</td></tr>
<tr><td colspan="2">Overall Percentage</td><td></td><td></td><td>80.1</td></tr>
<tr><td rowspan="3">Step 4</td><td rowspan="2">Change_NoChange</td><td>No Change</td><td>27</td><td>63</td><td>30.0</td></tr>
<tr><td>Change</td><td>13</td><td>283</td><td>95.6</td></tr>
<tr><td colspan="2">Overall Percentage</td><td></td><td></td><td>80.3</td></tr>
<tr><td colspan="6">The cut value is .500</td></tr>
</table>

Table 7, represents the classification table, which shows that the model correctly classifies 80.3 % of cases overall. The model sensitivity is 95.6 %, which is represented by the number of participants who indicated that they are willing to change and were also predicted by the model to have willing to change. The model specificity is 30%, which is represented by the number of participants who indicated that they have no willing to change and were correctly predicted by the model not to have willing to change. Table 7, shows also that the positive predictive value is 81.8%, which indicates that of all cases predicted as willing to change, 81.8% were correctly predicted. In addition, the negative predictive value is 67.5%, which indicates that of all cases predicted as not willing to change, 67.5% were correctly predicted.

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**Table 8: Variables in the Logistic Regression Equation**

| Step 4 | B | S.E. | Wald | df | Sig. | Exp (B) |
|---|---|---|---|---|---|---|
| Gated(1) by Status(1) | -1.772 | .518 | 11.710 | 1 | .001 | .170 |
| Car_substitution * Location_work | | | 41.026 | 4 | .000 | |
| Car_substitution(1) by Location_work(1) | -3.067 | .572 | 28.757 | 1 | .000 | .047 |
| Car_substitution(1) by Location_work(2) | -2.023 | .635 | 10.159 | 1 | .001 | .132 |
| Car_substitution(2) by Location_work(1) | .045 | .478 | .009 | 1 | .925 | 1.046 |
| Car_substitution(2) by Location_work(2) | -.400 | .397 | 1.011 | 1 | .315 | .671 |
| Commuter_Description * Shop_Grocery | | | 14.539 | 15 | .485 | |
| Commuter_Description(1) by Shop_Grocery(2) | -23.161 | 28328.409 | .000 | 1 | .999 | .000 |
| Commuter_Description(1) by Shop_Grocery(4) | -1.385 | 1.025 | 1.825 | 1 | .177 | .250 |
| Commuter_Description(1) by Shop_Grocery(5) | -23.355 | 40192.970 | .000 | 1 | 1.000 | .000 |
| Commuter_Description(1) by Shop_Grocery(6) | 19.061 | 23205.105 | .000 | 1 | .999 | 189682518.35 |
| Commuter_Description(2) by Shop_Grocery(2) | 1.096 | 1.215 | .814 | 1 | .367 | 2.993 |
| Commuter_Description(2) by Shop_Grocery(3) | -1.317 | 1.261 | 1.091 | 1 | .296 | .268 |
| Commuter_Description(2) by Shop_Grocery(4) | 1.131 | 1.291 | .767 | 1 | .381 | 3.098 |
| Commuter_Description(2) by Shop_Grocery(5) | 19.115 | 40192.969 | .000 | 1 | 1.000 | 200273647.95 |
| Commuter_Description(2) by Shop_Grocery(6) | -.608 | .552 | 1.210 | 1 | .271 | .545 |
| Commuter_Description(3) by Shop_Grocery(1) | 20.793 | 40192.969 | .000 | 1 | 1.000 | 1072535341.37 |
| Commuter_Description(3) by Shop_Grocery(2) | .216 | .637 | .116 | 1 | .734 | 1.242 |
| Commuter_Description(3) by Shop_Grocery(3) | 20.717 | 15104.412 | .000 | 1 | .999 | 993974116.32 |
| Commuter_Description(3) by Shop_Grocery(4) | -1.271 | .453 | 7.886 | 1 | .005 | .281 |
| Commuter_Description(3) by Shop_Grocery(5) | -1.190 | .669 | 3.163 | 1 | .075 | .304 |
| Commuter_Description(3) by Shop_Grocery(6) | -.155 | .412 | .142 | 1 | .707 | .856 |
| Car_captivity_3 * Density_GIS | | | .440 | 3 | .932 | |
| Car_captivity_3(1) by Density_GIS | -.919 | 2.290 | .161 | 1 | .688 | .399 |
| Car_captivity_3(2) by Density_GIS | 1.499 | 3.713 | .163 | 1 | .686 | 4.476 |
| Car_captivity_3(3) by Density_GIS | -.991 | 3.742 | .070 | 1 | .791 | .371 |
| Constant | 2.152 | .382 | 31.677 | 1 | .000 | 8.602 |

Table 8, shows the variables selected by the forward selection method including the following four interactions:

1. *Gated (1) by Status (1)*
2. *Car Substitution * Location Work*
3. *Commuter Description * Shop Grocery*
4. *Car Captivity 3 * Density GIS*

The logistic regression equation coefficients (B) associated with each of the selected interactions are in log-odds units. The logistic regression equation is:

***log(p/1-p)*** *= 2.152 -1.772 [Gated (1) by Status (1)] -3.067 [Car_substitution(1) by Location_work(1)] -2.023 [Car_substitution(1) by Location_work(2)] +0.45 [Car_substitution(2) by Location_work(1)] -0.4 [Car_substitution(2) by Location_work(2)] -23.161 [Commuter_Description(1) by Shop_Grocery(2)] -1. 385 [Commuter_Description(1) by Shop_Grocery(4)] -23.355 [Commuter_Description(1) by Shop_Grocery(5)] + 19.061 [Commuter_Description(1) by Shop_Grocery(6)] + 1.096 [Commuter_Description(2) by Shop_Grocery(2)] -……………………………………- 0.991 Car_captivity_3(3) by Density_GIS*

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Where *p* is the probability of being willing to change. The column labeled S.E. in Table 8, represents the standard error values associated with each of the coefficients. The columns labeled Wald and Sig. are the results for testing whether the coefficients are statistically significant. The column labeled "Exp(B)" is the odds ratio that is simply the exponential of B. These provide a more intuitive interpretation of the influence of each variable, representing the factor change in odds for a unit increase in the variable.

These equation coefficients tell the amount of increase (+ve coefficient) or decrease (-ve coefficient) in the predicted log odds of willingness to change that would be predicted by a 1-unit increase (or decrease) in the predictor, holding all other predictors constant. For example, for every one-unit increase in the Commuter_Description(2) by Shop_Grocery(2) interaction, we expect a 1.096 increase in the log-odds of willingness to change, holding all other predictors constant. Since SB are in log-odds units, they are difficult to interpret, so they are often converted into odds ratios.

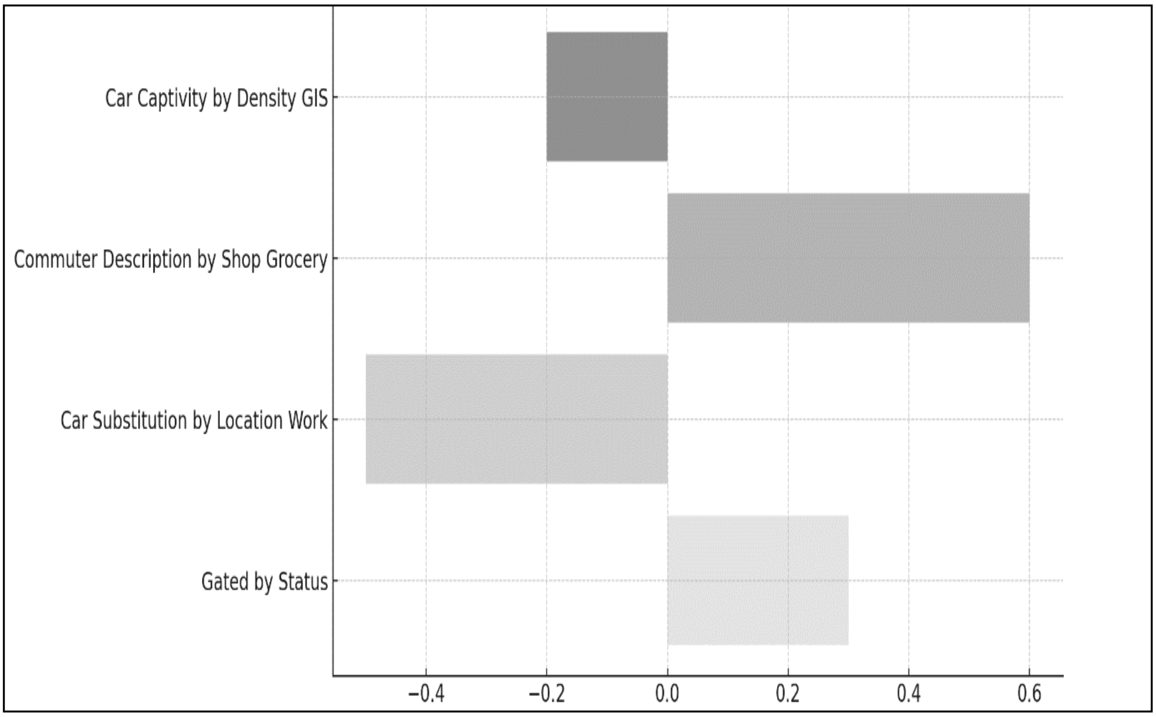


**Figure 6: Coefficient Value (Influence on Change Travel Mode)**

Figure 6, visualizes the significant variables and interactions. Each bar represents the estimated coefficient value (influence) of a specific variable or interaction on the likelihood of changing travel mode.

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Greater than 0.0 indicate a positive influence (increasing the likelihood of changing from car travel), while less than 0.0 represent a negative influence (decreasing the likelihood).

- **Gated by Employment Status**: A negative coefficient suggests that in gated communities, certain statuses are less likely to change travel mode.
- **Car Substitution by Location Work:** Different combinations of car substitution preferences and work locations have varying influences, with some combinations significantly decreasing the likelihood of changing travel mode.
- **Commuter Description by Shop Grocery:** Certain types of commuters combined with grocery shopping habits significantly influence travel mode decisions, though some coefficients seem unusually large, suggesting potential data issues or the need for further investigation.
- **Car Captivity by Density GIS:** This interaction shows a mixed influence on travel mode change decisions.

### 3.3 Conclusion

In the analysis of the study, demographic factors, travel patterns, and built environment variables emerge as key influencers. These variables, through their significant interactions, reveal intricate relationships that necessitate further examination for a comprehensive understanding, particularly to identify and rectify any data inconsistencies or outliers. Within the realm of built environmental factors, residents of high-density and gated communities exhibit distinct behaviors toward changing their travel modes.

Notably, those in gated communities with specific statuses tend to show a reluctance to shift away from car travel. Lifestyle choices, such as shopping habits and commuting patterns, also exert a considerable influence on these decisions. The impact is particularly pronounced when commuting patterns are considered alongside grocery shopping habits.

Work-related aspects, including the location of employment and preferences for car substitution, interact in ways that significantly shape travel mode choices. Demographic elements like gender further contribute to this complex interplay of factors, highlighting the multifaceted nature of the decision-making process related to travel mode choices.

In summary, the decision to permanently switch from conventional travel modes, such as cars, to alternative options is deeply influenced by an interplay of demographic characteristics, personal lifestyle habits, and the built environment. Studies like those by Handy, Cao, and Mokhtarian (2005) highlight the significant role of urban design and density in encouraging alternative travel choices.

Lifestyle factors, particularly routine activities like shopping and commuting, as examined by Schwanen and Mokhtarian (2005), have a profound impact on shaping long-term travel behavior. Demographic aspects, including age and gender, as noted in Crane's (2007) research, also play a critical role in these decisions. This suggests that fostering a sustainable shift in travel behavior requires comprehensive strategies that address these varied influences.

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Urban planning and policy-making need to be attuned to these nuances to effectively promote and support the adoption of more sustainable and environmentally friendly travel alternatives.

**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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