SSRG International Journal of Civil Engineering
ISSN: 2348-8352/ https://doi.org/10.14445/23488352/IJCE-V11I11P103

Volume 11 Issue 11, 23-35, November 2024

Original Article

Influence of Perceptive Utilities and Personality Traits on Route Choice by Commuters; A Case Study of Komarock-Nairobi Central Business District (CBD) Corridor

Jane Mabatsi[1], Zachary A. Gariy[2], Tulatia Mungathia[3]

[1,2,3]*Department of Civil, Construction and Environmental Engineering, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya.*

[1]*Corresponding Author : jane.mabatsi@students.jkuat.ac.ke*

Received: 03 September 2024 Revised: 07 October 2024 Accepted: 04 November 2024 Published: 30 November 2024

Abstract *- Traditional approaches to traffic assignment use time and cost as determining factors, thus not representing the complexity of human behavior and resulting in inaccuracies, which may cause underestimation or overestimation of traffic volumes. The study investigated the effects of perceptive utilities and personality traits on route choice among commuters within the Komarock-Nairobi CBD Corridor so as to increase accuracy in route choice modelling. A questionnaire measuring sensation seeking, spatial ability and familiarity with urban areas was administered to 267 commuters from the Komarock area and scores on these traits were correlated with commuters' route choices. For perceived utilities, commuters' ratings of perceived scenery and perceived insecurity on a Likert scale were correlated with route choice. Regression analysis and optimization in the R programme were employed to establish routes' utility functions and route assignment models that incorporate subjective traits. A negative correlation was observed between commuters' spatial ability and the tendency to change commute routes. A negative correlation was observed between perceived insecurity and frequency of route selection, confirming that insecurity on a route discourages usage. A positive correlation was observed between perceived scenery and route choice decision, confirming that scenic routes attract users. The incorporation of perceived insecurity and scenery into the route utility function resulted in a decrease in the randomizing error of the function. Integrating perceived utilities and personality traits improves route choice modeling accuracy, and this should be implemented to improve route choice modelling and overall transportation planning.*

Keywords *- Traffic assignment, Route choice, Perceptive utilities, Personality traits, Central Business District.*

1. Introduction

Travel demand and traffic forecasting are essential for planning and providing transport infrastructure. For new road construction, traffic forecasts are essential in determining the appropriate pavement design and geometric design that will provide an acceptable level of service.

Where roads have been constructed, and there is a need to improve operations, traffic forecasts are needed to evaluate the effectiveness of alternative improvement options [1]. Analysts are, therefore, required to develop methodical approaches that can help predict changes in traffic volumes.

The goal is to provide a sufficient highway level of service and acceptable pavement ride quality for future traffic volumes. The four-step process of trip generation, trip distribution, modal choice, and traffic assignment/route choice is commonly used to forecast travel demand.

It is widely recognized that an accurate traffic forecast is difficult. Over the years, analysts have persisted in the development and refinement of a wide variety of travel demand and forecasting techniques. The traffic assignment is a particularly time consuming and data-intensive process [2]. The process of travel demand forecasting is complicated by the fact that it requires accurate regional economic forecasts as well as accurate forecasts of highway users' social and behavioral attitudes regarding trip-oriented decisions. Most basic approaches to traffic assignment, such as the diversion curves approach, minimum path (all-or-nothing) assignment and minimum time path with capacity restraint, use time and cost of travel as the determining factors in trip assignment [3]. It is assumed that motorists will select the route that represents minimum travel time and cost. Focus on travel cost and travel time is problematic because it does not represent the overall complexity of human behavior, thus resulting in inaccuracies. Inaccurate traffic assignment modeling may result in either overestimation or underestimation of traffic volumes on links. Underestimation of traffic volumes leads to traffic congestion on roads long before their design period elapses. This may explain why many roadway projects fail to deliver promised travel time savings and are thus perceived to be an unjustifiable loss of resources. On the other hand, overestimating traffic volumes results in over-provision of infrastructure, thus tying down limited resources that would have been better spent on other development projects.

This study postulates that in addition to the travel time and travel costs, perceptive utilities and personality traits significantly affect the route choice behavior of travelers, and they should, therefore, be incorporated into the traffic assignment process so as to increase accuracy in the modelling process. In this study, personality traits are psychological factors or latent variables that are deemed likely to affect decision-making regarding route choice. The study narrows down to three latent variables that can be aggregated for planning purposes. These are familiarity with the urban area, spatial ability of travelers and sensation seeking among travelers.

On the other hand, perceptive utilities refer to feelings and emotions or experienced utility, which is closely related to satisfaction and subjective well-being [4]. This study evaluated the effects of two perceptive utilities on route choice. These are, perceived scenery and perceived safety. Increasing the accuracy of route choice behavior by incorporating traveler's subjective perceptions and individual traits, as this study sought to do, produces more realistic metrics for use in infrastructure planning and upgrade efforts.

2. Literature Review

Trip assignment (route choice) is the last stage in the four-stage demand modelling. It is used to assign travel demands to the road network and predict network flows that are associated with future planning scenarios based mainly on link travel times. It is the process of finding the specific path that trips use to travel from their origin to their destination [5]. As the core of traffic assignment and simulation procedures, route choice models allow for predicting traffic conditions and forecasting travelers' reactions under future hypothetical scenarios. As the representation of individual behavior, route choice models allow for understandinghoices on transportation networks [6]. Route choice modelling is problematic given the complexity of representing human behavior, the lack of traveler's knowledge about network composition, the uncertainty of traveler's perception of route choice characteristics and the insufficiency of information about traveler's preferences.

Perfect rationality has widely been used in modeling traveler route choice behavior. For perfect rationality, travelers are required to have perfect judgement and forecasting ability, and they must have rational common cognition [7] which are unnatural assumptions that pertain to human behaviour. Aspects of human perceptions and other latent variables contribute to the way in which travelers make travel decisions.

2.1. Personality Traits and Route Choice Decision

A number of disciplines have shown a general interest in enhancing route choice modelling by considering the incorporation of psychological factors affecting decision-making. Prato et al. [6] for example, found that mnemonic, spatial and time-saving abilities seem to have a positive correlation with the preferences of individuals with respect to route attributes in the sense that probably individuals with these skills tend to look for better alternatives and to remember to use them. Albert, et-al. [8] conducted an in-laboratory experiment aimed at exploring the impact of various personality factors on route-choice behavior in the presence of partial pre-trip travel time information. The specific factors they explored were geographic ability and sensation-seeking characteristics. Participants with varied levels of familiarity were presented with real-world networks in a laboratory setting, and participants were asked to estimate travel time between two routes and make a choice. They found that while the variables related to perceived and realized travel times are important, the personality factors are also significant. Drivers with lower geographic abilities tended to use the main route more often and to switch their routes less often, compared to those with higher capabilities.

2.2. Perceptive Utilities and Route Choice Decision

Studies have been conducted to assess the implication of perceived utilities on travel behaviour. Beecroft & Pangbourne [9] conducted a study focused on understanding the interaction between transport technologies and user needs and perceptions in supporting personal security in travel by public transport. They found that transport providers are concerned with general security issues and also focus on safety (freedom from accidents). They further established that according to respondents in their survey, personal security ought to comprise a combination of three aspects from the perspective of an individual: Security, which is freedom of threat from other people, for example, terrorism, violence, theft, or intimidating behaviour; safety, which is freedom from the impacts of accidents, for example vehicle accidents, safe interchange environments, preventing slips and trips; and confidence, which is freedom from discomfort, for example, a smooth ride quality, and from fear, for example, from not knowing how to travel, from accident, from threat. Beecroft and Pangbourne [9], applied technology to examine personal security implications. They found that travelers considered the availability of travel information, proper standards and regulations by the national government, and intergovernmental cooperation as priority areas for enhancing personal security in public transport. Nordfjærn & Rundmo [10] studied differences in risk evaluations according to whether individuals had been exposed to adverse security events in transport during the last five years. Using a sample size of 1043 Norwegian urban public, they found that individuals exposed to adverse security events in public transport reported substantially higher risk perception of experiencing security issues in such transport than those who were not exposed. Exposed individuals also reported higher probability judgements and more worry about experiencing injury in public transport. Their path model showed that high probability judgements of experiencing injury in public transport were related to a lower intention of using such transport. In contrast, corresponding worry in the private motorized sector predicted a stronger intention to use public transport. This study clearly brings out the implication of perceived security on modal choice but does not speak to its implication on other travel decisions, such as route choice.

In their study, Vos et al. [4] found that while travel mode choice tends to depend on objective characteristics of the built environment (density, diversity and design) and travel modes (travel time and cost) as well as travel-related attitudes and other subjective factors, the experienced utility (travel satisfaction) can be affected by this decision utility (mode choice), but might also be affected by characteristics of the built environment and travel-related attitudes.

2.3. Literature Summary and Research Gaps

Studies ([9], [11], [12], [13],) have examined the role of attitudinal variables and perceptive utilities such as comfort and convenience on travel decisions. These studies have established a relationship between these latent variables and travel decisions, such as mode choice. Beecroft & Pangbourne [9], for example, showed that travelers who perceived public transport to be safer chose it more often as compared to private transport. This information has been applied in nudging travelers to select public transport by availing travel information and ensuring proper standards and regulations by the national government. The fact that these latent factors affect mode choice behavior may be a pointer to the fact that these variables have the potential to affect route choice behavior as well. This study will explore how some of these factors affect route choice decisions.

In relation to the effect of latent factors on route choice, studies ([8], [14], [15]) have explored the impacts of various personality traits on travelers' tendency to change their routes during travels. They explored how factors such as geographic ability, sensation seeking, urban area familiarity and partial-pre-trip travel information affects the switching of routes. They also established that these factors affected remembrance and repeated selection of routes. These studies concentrated on route switching during travelling and how it is affected by latent variables such as familiarity with the urban area. Prato et al. [6] found that travelers familiar with the urban environment tend not to switch their routes and that drivers may avoid the shortest route if they had a bad experience on the route. Albert et al. [8] found that drivers who scored higher on sensation-seeking tended to switch their routes more frequently compared to other drivers. Albert et al. [8] considered this information useful for Advanced Traveler Information Systems (ATIS). The results of these studies have been instrumental in explaining how latent factors affect travelers' decisions in switching routes but fail to explain the extent to which these factors may affect the initial decision of route choice. This current study seeks to fill this gap, especially for scenarios where route switching may not be very feasible, and to further provide models based on utility theory that may be used to incorporate these effects in the route selection process.

The interaction between perceived security and the choice of modes that travelers make has been extensively studied ([9], [10], [16]). A causal relationship has been established between perceived security and the tendency of travelers to choose a mode. For example, travelers who had experienced accidents driving on certain roads were likelier to choose public transport, and those who experienced accidents/incidents in public transport preferred to drive [10]. In their path model, Nordfjærn & Rundmo [10], showed that high probability judgements of experiencing injury in public transport were related to a lower intention of using such transport, whereas corresponding worry in the private motorized sector predicted a stronger intention to use public transport. These studies show that perceived security heavily affects mode choice and is likely to affect other travel decisions, such as route choice decisions. This study will examine the extent to which perceived security affects route choice decisions to complement the work done on the nexus between perceived security and travel decision.

Static traffic assignment models have been used to incorporate the irrationality of human behavior in making travel decisions. Li et al. [17] developed Stochastic User Equilibrium (SUE) models, which are probabilistic route choice model that reasonably allows for travelers' imperfections in path costs and choose the route that minimizes travelers' perceived travel costs given a set of routes. Stochastic User Equilibrium (SUE) assumes that travelers make errors and they seek the "minimum perceived travel time". The models introduce a randomizing factor that accounts for travelers' imperfections. The higher the randomizing factor, the less accurate the model is considered. This study seeks to augment the accuracy of SUE models by making modifications to the randomizing factor in the probabilistic model to incorporate measured perceived utilities and personality traits. This will reduce the recorded randomizing factor, thereby increasing the accuracy of the model.

3. Materials and Methods

The study was a survey that employed a questionnaire to collect data on the aspects of travelers' characteristics; their scores on personality traits of sensation seeking, spatial ability and familiarity with urban areas; their scores on perceived utilities of insecurity and scenery and their route choice behaviour in a typical commuter week. The Cochran [18] formula for a large population was used to determine the sample size. At a sampling error of 6.5%, a sample size of 267 was obtained. 400 questionnaires were administered to allow for 30% extra data to be used in model validation.

Quota sampling was employed to ensure that the sample was representative of the commuters in the Komarock area. 30% of the drivers interviewed were public transport drivers, and interviews were conducted at different bus stops along the study routes. To ensure that the sample reflected the population proportions, quotas were set for each estate within the study area, and respondents were recruited to meet them.

3.1. Route Choice Selection

The study corridor has three main distinct routes that can be used and connected to other minor routes, as shown in Table 1.

Table 1. Key study routes

Route	Length (km)	Average Travel Time (Free flow) in minutes
Jogoo Road-Kangundo Road	16	29
Jogoo Road – Manyanja Road	14	31
Thika Road-Outering Road	17	30

Respondents were required to indicate the number of times they selected each route for mandatory trips (i.e., to work or to school in the mornings and evenings) and for non-mandatory trips such as shopping during the weekend. The frequency of selection of each route constituted the dependent variable.

3.2. Measuring Personality Traits

Personality traits of sensation seeking, spatial ability and familiarity with the urban area were measured in this study as follows.

The study employed the widely used self-report standardized measure to assess sensation seeking, sensation seeking scale form V (SSS-V) [19]. The sensation-seeking scale consists of four distinct components: adventure-seeking, experience-seeking, disinhibition and boredom susceptibility. On the sensation-seeking scale, respondents scored either 1 or 0 on questions that were designed to evaluate their profile depending on the four domains. For each of the four components, 0-3 means a low score, 4-6 is a medium score, and 7-10 is a high score. Correlation analysis was based on respondents' scores on each of the sensation-seeking traits and their route choice decisions.

The study used the self-report measure of spatial ability developed by Hegarty et al. [20] known as the Santa Barbara Sense of Direction scale (SBSOD). The scale measures one's ability for spatial updating and acquisition of spatial knowledge at different scales. The self-assessment questionnaires evaluated broader aspects of spatial abilities using standard questions. A typical question from the questionnaire asked respondents to rate on a five-point Likert scale a statement such as, "I can usually remember a new route after I have traveled it only once.". The Likert scale proposed by Likert [21] provides a summated assessment of respondents' attitudes by assuming the existence of a latent continuous variable whose value characterizes the respondents' attitudes and opinions. The Likert scale scores were correlated with route choice decisions.
To measure familiarity with the urban area, the study employed an objective-aided recall technique. The respondents scored on knowledge of identified landmarks/ known places along the routes. The questions required a simple "yes" or "no" answer for identified landmarks/popular places. For a positive identification, the respondent scored 1 and 0 otherwise. For analysis, the total scores on familiarity were correlated with route choice decisions.

3.3. Measuring Perceived Utilities

The aspects of perceptive utilities analyzed in this study were perceived insecurity and perceived scenery of routes. They were measured as follows.

To measure perceived scenery, different scenes of each route were presented to participants, and they were asked to rate each scene on a 5-point preferential scale ("How much do you like the scene"). Therefore, each respondent had a score rating for each scenery presented and a total rating of scenery for the whole route. The ratings for the scenery of each route were used for correlation with the likelihood of selection of that route.

Perceived insecurity was measured as a factor of both route safety and route security. To measure the aspects of road safety, respondents were asked to reveal whether they had experienced or know people who had experienced an accident on route a particular route. They were further required to reveal how many times they or people they know had experienced accidents and to what severity on a 5-point scale where '1' corresponded to a light incident and '5' corresponded to a severe accident. To measure route security, respondents were asked to reveal their experiences of criminal incidents. They were required to disclose whether they had been or knew people who had been victims of criminal incidents on the routes. They also responded to how frequently they or people they know had been victims and to rate the severity of the criminal incident on a 5-point scale where '1' corresponded to light incidents such as pickpocketing and '5' corresponded to serious incidents such as robbery. The total scores on direct and indirect experiences of insecurity and safety incidents were summed to give the total perceived insecurity for each route, and analysis was done for the relationship between the perceived insecurity and the likelihood of choosing a given route.

3.4. Questionnaire Validation

Of the five scales utilized in the survey, two of them were standardized questionnaires that established consistency and minimal variations. The Sensation Seeking Scale Form V (SSS-V) used to measure sensation, and the Santa Barbara Sense of Direction (SBSOD) Scale used for measuring individuals' spatial ability are well-regarded tools.

The Santa Barbara Sense of Direction (SBSOD) Scale has a Cronbach's alpha typically reported around 0.88, which indicates high internal consistency, while the Sensation Seeking Scale Form V (SSS-V) has a Cronbach's alpha typically reported between 0.79 and 0.83. The scales used to measure familiarity with urban areas, perceived scenery, and perceived security were subjected to a reliability test to measure consistency, with the results shown in Table 2.

Table 2. Reliability tests for survey scales

Variable	Cronbach's Alpha	No. of Items
Familiarity with urban area	.740	18
Perceived Scenery	.713	15
Perceived security	.762	24

With Cronbach's Alpha values of over 0.7, the results imply that the items used to measure personality traits and perceptive utilities were reliable, consistent, and, therefore, acceptable.

3.5 Modelling of Route Choice Behavior as Influenced by Personality Traits and Perceived Utilities

This study modelled the influence of personality traits and perceived utilities on route choice based on the concept of SUE. SUE assumes that travelers make errors and they seek the "minimum perceived travel time", and decisions are based on their perceptions of their travel time rather than the actual travel time. The modelling process started with the logit route choice model. The assumption was that the utility of using the r^{th} path between origin *i* and destination *j*, U_{ijr} is given by Equation 1 below:

$$U_{ijr} = -\theta C_{ijr} + \varepsilon_{ijr} \qquad (1)$$

Where:

C_{ijr} = measured travel time for route r

θ = is a positive parameter associated with a random cost component used to control the spread of trips among routes.

ε_{ijr} = is a random term for route r.

Based on the same logit utility model, the probability of selecting a route r is given by Equation 2:

$$P_r^{ij} = \frac{e^{(-\theta c_{ijr} + \varepsilon_{ijr})}}{\sum_r e^{(-\theta c_{ijr} + \varepsilon_{ijr})}} \qquad (2)$$

This study modified Equation 2 to incorporate perceived utilities that were found to affect route choice decisions. Therefore, the modified utility function is as given by Equation 3.

$$U_{ijr} = -\theta C_{ijr} + \theta_1 x_1 + \theta_2 x_2 \ldots. + \varepsilon'_{ijr} \qquad (3)$$

Where:

x_1, x_2,….. are personality traits and perceived utilities found to influence route choice.

θ_1, θ_2,….. are the factors associated with variables x_1, x_2….

ε'_{ijr} is the new error term for route r

From Equation 3, the new probability of selecting a route r, therefore, is as presented in Equation 4:

$$P_r^{ij} = \frac{e^{(-\theta C_{ijr} + \theta_1 x_1 + \theta_2 x_2 \ldots + \varepsilon'_{ijr})}}{\sum_r e^{(-\theta C_{ijr} + \theta_1 x_1 + \theta_2 x_2 \ldots + \varepsilon'_{ijr})}} \qquad (4)$$

This study calibrated for the values x_1, x_2,…, θ_1, θ_2,…and ε'_{ijr} to establish a modified route choice model that incorporates personality traits and perceived utilities.

4. Results and Discussion

The study had three specific objectives: (i) assess the effect of personality traits on commuters' choice of route, (ii) assess the effect of perceptive utilities on commuters' choice of route and (iii) model commuters' route choice behavior as influenced by perceptive utilities and personality traits.

4.1. Travelers' Characteristics

The desired sample size of the study was 267, but data was collected for 381, which included an extra 114 (30%) for model validation. A good response rate of 85.6% was recorded, 26% of which were female and 74% of the respondents were male amongst the private car owners. For the public vehicle drivers, only 3% were female, while 97% were male. There was a normal age distribution among both private car owners and public transport drivers, as shown in Figures 1 and 2.

4.2. Route Choice Behaviour

Commuters were required to indicate their remembered frequency of use of each route for a typical work week. In Komarock, private car owners and public vehicle drivers have access to multiple routes and tend to change their routes during the work week. This study observed that more than half of the commuters changed their routes during a typical work week, as illustrated in Figure 3.

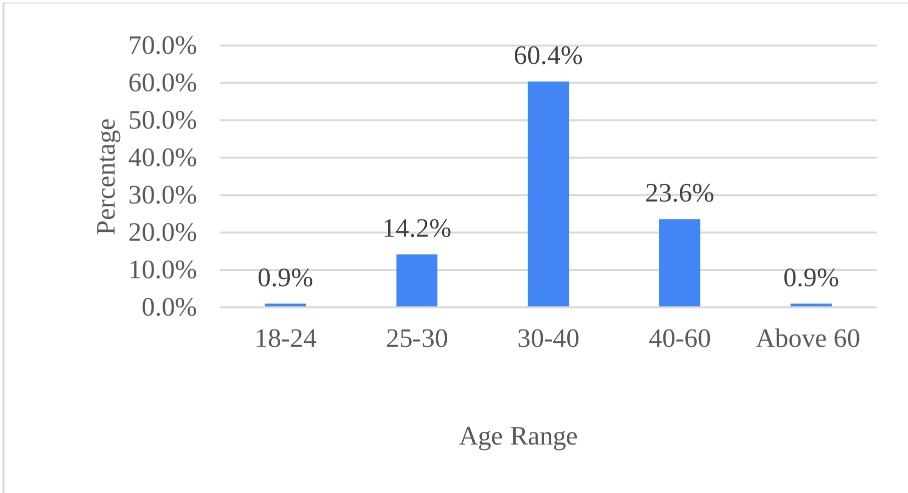

Fig. 1 Age distribution among public transport drivers

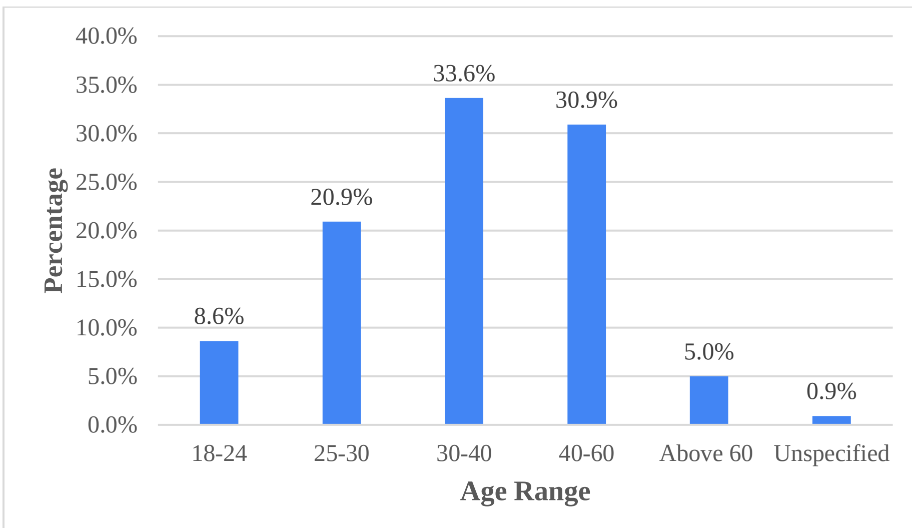

Fig. 2 Age distribution among private car owners

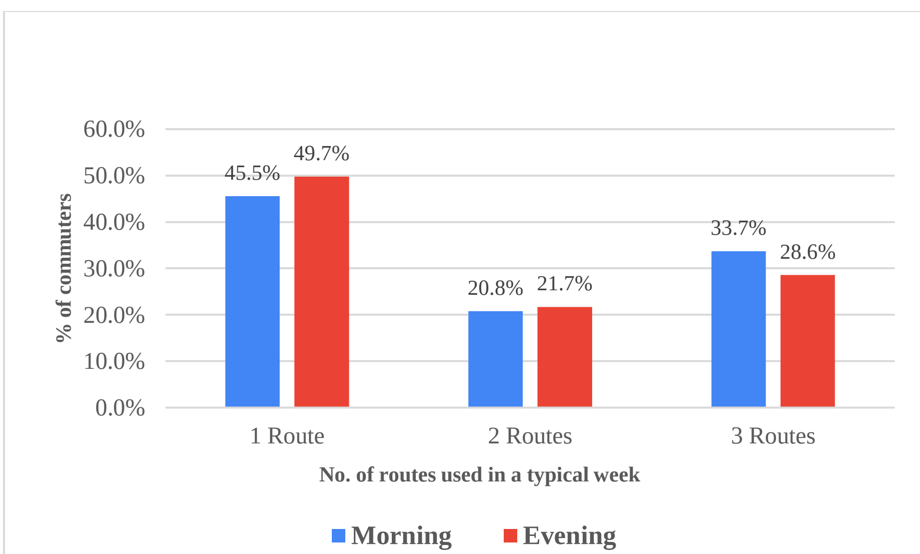

Fig. 3 Choice of routes by commuters in komarock

45.5% of commuters reported sticking to one route during the morning commute all week, while 20.8% and 33.7% reported alternating between two and three routes, respectively. Therefore, at 54.5%, most commuters use at least more than one route for morning commutes. In the evening, 49.7% of commuters reported sticking to one route for the commute. 21.7% reported alternating between two routes, and 28.6% reported using three of the routes available. Therefore, the majority of the commuters (51.3%) do change their commute route. It is, therefore, implicit that commuters in the Komarock-CBD corridor have options of routes to pick from. Many commuters who reported sticking to one route also reported working along the same route, and therefore, they did not have multiple route choices available to them.

4.3. Perceived Travel Time and Route Choice

For each route that commuters reported using, they were required to indicate their perceived travel time and their remembered frequency of using the route per week, both in the morning and evening commute. A striking disparity was noted between perceived travel time and route selection. The perceived shortest route was not always the most frequently selected route by the commuters, as illustrated in Figure 4.

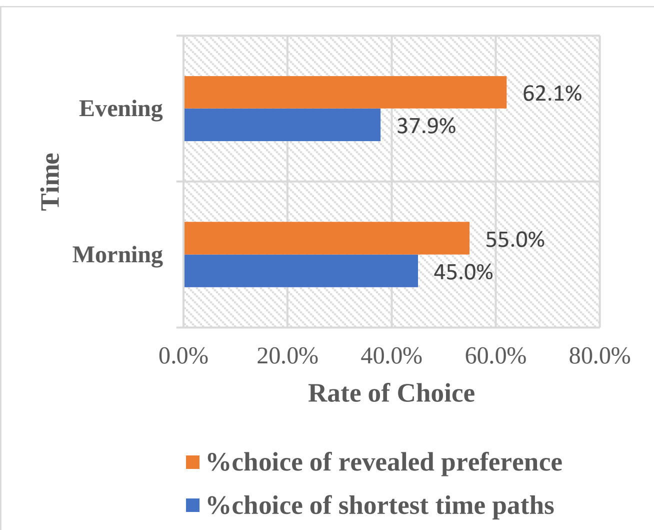

Fig. 4 Rate of choice of perceived shortest path

Individually, only 37.9% of the commuters selected the perceived shortest route most frequently for the evening commute. On the other hand, in the morning, 45% of commuters selected the route they perceived to have the shortest commute time most frequently. This may indicate that commuters have more urgency in the morning than in the evening. Additionally, these findings reinforce the hypothesis of this study that commuters don't base their travel decisions entirely on the travel cost or time. It is reported that less than 50% of drivers chose the shortest/fastest route from their origins to destinations [17, 18]. The results of this study were consistent with these observations. Therefore, travel costs or time cannot be the only factor affecting the route choice decision. It is, therefore, crucial to understand other factors influencing drivers' route choice decisions and how to satisfy them.

4.4. Influence of Personality Traits on Route Choice

No relationship between the frequency of route selection and individuals' sensation-seeking traits for all the routes was recorded for private car owners, unlike among the public vehicle drivers. For Manyanja Road, which was the mean shortest perceived route, there was a statistically significant correlation between the drivers' frequency on the route and disinhibition and boredom susceptibility.

Disinhibition showed a positive correlation of 0.477 with the choice of route for Manyanja Road, while boredom susceptibility showed a positive correlation of 0.314. This means that, for public transport drivers, drivers who scored higher on disinhibition and boredom susceptibility chose the mean perceived shortest route (Manyanja Rd) more frequently. Shiftan et al. [19] demonstrated that a tendency to choose a route that is perceived as faster but incurs larger travel time variance can be predicted by sensation seeking.

On the other hand, Albert et al. [7] showed that weak correlations exist between the sensation-seeking factors, in particular experience seeking, and the number of route switches. Drivers who scored higher on sensation seeking tended to switch their routes more frequently and to use the alternative route more often than the route considered as the main route.

The results of this study may be attributed to the fact that, unlike private commuters, public vehicle drivers have to make the same trip several times a day and therefore, boredom and the need to break monotony play a significant role in route choice decisions.

When correlation analysis was conducted between commuters' scores on spatial ability and the frequency with which they reported choosing a certain route, no statistically significant relationship was found between any of the routes for public transport drivers and private car commuters in Komarock. In contrast, a significant negative correlation was observed between commuters' spatial ability and their likelihood to change routes during commutes, as shown in Tables 3 and 4.

Table 3. Correlation between spatial ability and the tendency of private car owners to change routes

	No. of Routes Selected for Morning Commute	No. of Routes Selected for Evening Commute
Commuter's spatial ability	-.464**	-.354**

**. correlation is significant at the 0.01 level (2-tailed)

Table 4. Correlation between spatial ability and the tendency of public transport drivers to change routes

	No. of Routes Selected for Morning Commute	No. of Routes Selected for Evening Commute
Commuter's spatial ability (Max. 75)	-.278*	-.193*

*. correlation is significant at the 0.05 level (2-tailed)

Table 5. Correlation between familiarity with urban area and frequency of route choice

	Frequency_ Kangundo Rd.	Frequency_ Manyanja Rd.	Frequency_ Thika Rd.
Commuters' familiarity with urban area	.085	.193	.055

Table 6. Correlation between perceived insecurity and frequency of route choice

	Frequency_Kangundo Rd.	Frequency_Manyanja Rd.	Frequency_Thika Rd.
Perceived insecurity_ Kangundo Rd.	-.213*		
Perceived insecurity_ Manyanja Rd.		-.213*	
Perceived insecurity _Thika Rd.			-.252*

*. correlation is significant at the 0.05 level (2-tailed)

The findings of this study, therefore, show that the higher the driver's spatial ability, the lower their tendency to change routes during commutes. The case of the Komarock-CBD corridor confirms that once drivers with high spatial ability establish the best alternative, they remember to use it rather than switching.

This study agrees with a similar study by Prato et al. [8] that established that spatial and time-saving abilities seem to have a positive correlation with the preferences of individuals with respect to route attributes in the sense that probably individuals with these skills tend to look for better alternatives and to remember to use them. Familiarity with the urban area did not show a significant correlation with elements of route choice, as shown in Table 5.

Furthermore, this study did not find any relationship between familiarity with the urban area and the tendency to select multiple routes in a commute week. In contrast, previous studies have shown a relationship between familiarity with the urban area and route choice behavior. Albert et al. [7] found that the extent of the familiarity factor was negatively related to the frequency of switching routes.

Prato et al. [8] on the other hand, found that familiarity appeared to have a negative correlation with the preferences of individuals for route attributes in the sense that, possibly, individuals who are familiar with the urban area characteristically do not tend to search for better alternative routes even if their choice is not optimal. In this study, this relationship may not have been pronounced because of the nature of the respondents.

On average, commuters in the Komarock-CBD corridor were very familiar with their urban environment. On a maximum score of 17, on average, the commuters, including public transport drivers, recorded a mean of 15.95 with a low standard deviation of 1.925. Therefore, respondents who had minimal familiarity with urban areas were few, thus making it impossible to establish how familiarity with urban areas influences route choice decisions.

4.5. Influence of Perceived Utilities on Route Choice

A significant negative correlation was observed between perceived insecurity and frequency of route selection both for private car owners and public transport drivers for all routes of the study, as shown in Table 6.

The negative correlation between perceived insecurity and frequency of route selection confirms that motorists are less likely to select routes they perceive to be insecure, given options.

This further means that improving a road's perceived security and safety through factors such as clearer signage, improved road markings, and lighting would result in drivers selecting the route more frequently.

Previously, studies have focused on the influence of insecurity on route choice decisions for pedestrians and not motorists. Basu et al. [20] and Arellana et al. [21] found that pedestrians' perceptions of attractiveness, safety and security are the most critical factors determining the walkability of a route. This study shows that these factors equally affect the decision making of motorists.

Table 7. Correlation between route choice and perceived scenery

	Frequency_Kangundo Rd.	Frequency_Manyanja Rd..	Frequency_Thika Rd.
Perceived scenery_ Kangundo Rd.	.196*		
Perceived scenery_ Manyanja Rd.		.174*	
Perceived scenery _Thika Rd.			.250**

*. correlation is significant at the 0.05 level (2-tailed)
**. correlation is significant at the 0.01 level (2-tailed)

A correlation analysis was conducted between perceived scenery and frequency of route selection, and the results are shown in Table 7.

A positive correlation between perceived route scenery and frequency of route choice was observed among private car owners but not public transport drivers. This means that improving the scenery for a route through elements such as landscaping and art installations results in increased selection among private car owners.

Public transport drivers' route choice decisions may not be significantly affected by route scenery because public transport drivers operate on fixed routes, and their initial route decision seeks to maximize profit. On the other hand,private car commuters have the flexibility to attach a level of importance to the scenery of a route, even if it is not the only factor that determines their route choice decision.

4.6. Multicollinearity

The two independent variables (Perceived scenery and perceived security) that were found to have a significant bearing on route choice decisions were assessed for multicollinearity. The Variance Inflation Factor (VIF) and the Tolerance values were evaluated and showed results as presented in Table 8.

Table 8. Multicollinearity statistics

	Collinearity Statistics	
	Tolerance	VIF
(Constant)		
Perceived Scenery	0.756	1.322
Perceptive Security	0.949	1.054

The tolerance value for perceived scenery is 0.756, suggesting no alarm to warrant multicollinearity. The tolerance value close to 1 implies very low multicollinearity. The corresponding VIF value for the perceived scenery is 1.322. The tolerance value for perceived security is 0.949, with a corresponding VIF of 1.054, suggesting no cases of multicollinearity.

4.7. Modeling of Influence of Personality Traits and Perceptive Utilities on Route Choice

The factors that were found to significantly influence route choice decisions in this study were perceived insecurity and perceived scenery.

Multinomial Logistic Regression (MNL) was used to develop the utility equations and associated probabilities for route selection. The following assumptions were made:

- The probability of choosing any of the three routes of the study is not affected by the presence or characteristics of other routes (Independence of irrelevant alternatives)
- The utility function is assumed to be a linear combination of the attributes, i.e., travel time, insecurity and scenery (Linearity of utility function)
- The error term of the utility function is assumed to be independently distributed.
- All three study routes are available to every commuter in each choice situation.

This study incorporated the two factors into the logit route assignment model to formulate a model of the form.

$$P_r^{ij} = \frac{e^{(-\theta C_{ijr} + \theta_1 x_1 + \theta_2 x_2 + \varepsilon'_{ijr})}}{\sum_r e^{(-\theta C_{ijr} + \theta_1 x_1 + \theta_2 x_2 + \varepsilon'_{ijr})}}$$

Where:
$U_{ijr} = -\theta C_{ijr} + \theta_1 x_1 + \theta_2 x_2 + \varepsilon'_{ijr}$. is the route utility model for a route r.
x_1 is the score on perceived insecurity and θ_1 is the associated factor.
x_2 is the score on perceived scenery and θ_2 is the associated factor.

The measured peak hour travel time was used to calculate the cost of each route, and the revealed frequency of route selection was used to calculate the probability of selecting the three routes on the Komarock-CBD corridor. The results are shown in Table 9.

Table 9. Measured travel time and route selection probabilities during peak time

Route	Peak Hour Travel Time (Minutes)	Probability of Route Selection
Jogoo Rd.-Kangundo Rd.	65	0.547
Jogoo Rd.-Manyanja Rd.	78	0.415
Thika Rd.-Outer Ring Rd.	74	0.038
Total		1.000

From the measured travel time (travel cost), the routes have the following utility functions:
Kangundo Road: $U_k = -65\theta_k + \varepsilon_k$
Manyaja Road: $U_m = -78\theta_m + \varepsilon_m$
Thika Road: $U_k = -74\theta_t + \varepsilon_t$

With the following associated probabilities of route selection (route assignment models):

Probability for Kangundo Road (P_k)
$P_k = 0.547 = \frac{e^{(-65\theta_k+\varepsilon_k)}}{e^{(-65\theta_k+\varepsilon_k)}+e^{(-78\theta_m+\varepsilon_m)}+e^{(-74\theta_t+\varepsilon_t)}}$

Probability for Manyanja Road (P_m)
$P_m = 0.415 = \frac{e^{(-78\theta_m+\varepsilon_m)}}{e^{(-65\theta_k+\varepsilon_k)}+e^{(-78\theta_m+\varepsilon_m)}+e^{(-74\theta_t+\varepsilon_t)}}$

Probability for Thika Road (P_t)
$P_t = 0.038 = \frac{e^{(-74\theta_t+\varepsilon_t)}}{e^{(-65\theta_k+\varepsilon_k)}+e^{(-78\theta_m+\varepsilon_m)}+e^{(-74\theta_t+\varepsilon_t)}}$
and $P_k + P_m + P_t = 1.000$

R programming software was used to optimize and calibrate the values θ_k and ε_k; θ_m and ε_m and θ_t and ε_t which were found as follows:

θ_k = 0.01028
ε_k = -0.000476
θ_m = 0.00501
ε_m = 0.000612
θ_t = 0.02696
ε_t = -0.000466

From the results of the optimization process, an average absolute error in the route choice assignment is found to be 0.000518. It is also observed that, with a coefficient of 0.02696, Thika Road is the route that is most sensitive to time as an influencing factor in route choice decisions.

4.8. Modified Route Choice Models

To modify and improve the route assignment functions, the utility functions were modified to incorporate the effect of perceived insecurity and perceived scenery. The goal was to reduce the error factors ε while holding the θ factors constant. Therefore, modified utility functions in the form $U_{ijr} = -\theta C_{ijr} + \theta_1 x_1 + \theta_2 x_2 + \varepsilon'_{ijr}$ were as follows:

Kangundo Road: $U_k = -0.01028t_k + \theta_{1k}x_{1k} + \theta_{2k}x_{2k} + \varepsilon'_K$

Manyaja Road: $U_m = -0.00501t_m + \theta_{1m}x_{1m} + \theta_{2m}x_{2m} + \varepsilon'_m$

Thika Road: $U_t = -0.02696t_t + \theta_{1t}x_{1t} + \theta_{2t}x_{2t} + \varepsilon'_t$

Where:
x_1 and x_2 are scores on perceived insecurity and perceived scenery, respectively, while θ_1 and θ_2 are the associated coefficients. ε'_K, ε'_m, and ε'_t are the modified error factors.

Using the modified utility functions, the route assignment equations become:

$$P_k = \frac{e^{(-0.01028t_k+\theta_{1k}x_{1k}+\theta_{2k}x_{2k}+\varepsilon'_K)}}{e^{(-0.01028t_k+\theta_{1k}x_{1k}+\theta_{2k}x_{2k}+\varepsilon'_K)}+e^{(-0.00501t_m+\theta_{1m}x_{1m}+\theta_{2m}x_{2m}+\varepsilon'_m)}+e^{(-0.02696t_t+\theta_{1t}x_{1t}+\theta_{2t}x_{2t}+\varepsilon'_t)}}$$

$$P_m = \frac{e^{(-0.00501t_m+\theta_{1m}x_{1m}+\theta_{2m}x_{2m}+\varepsilon'_m)}}{e^{(-0.01028t_k+\theta_{1k}x_{1k}+\theta_{2k}x_{2k}+\varepsilon'_K)}+e^{(-0.00501t_m+\theta_{1m}x_{1m}+\theta_{2m}x_{2m}+\varepsilon'_m)}+e^{(-0.02696t_t+\theta_{1t}x_{1t}+\theta_{2t}x_{2t}+\varepsilon'_t)}}$$

$$P_t = \frac{e^{(-0.02696t_t+\theta_{1t}x_{1t}+\theta_{2t}x_{2t}+\varepsilon'_t)}}{e^{(-0.01028t_k+\theta_{1k}x_{1k}+\theta_{2k}x_{2k}+\varepsilon'_K)}+e^{(-0.00501t_m+\theta_{1m}x_{1m}+\theta_{2m}x_{2m}+\varepsilon'_m)}+e^{(-0.02696t_t+\theta_{1t}x_{1t}+\theta_{2t}x_{2t}+\varepsilon'_t)}}$$

From the field data:
P_k = 0.385, P_m = 0.443 and P_t =0.172
$t_k = 65$, $t_m = 78$ and $t_t = 74$
$x_{1k} = 14$, $x_{1m} = 16$, and $x_{1t} = 15$
$x_{2k} = 10$, $x_{2m} = 10$, and $x_{2t} = 11$
Furthermore, since the initial error in the route assignment has to be modified to be a factor of perceived insecurity and perceived scenery:
$\theta_{1k}x_{1k} + \theta_{2k}x_{2k} + \varepsilon'_K$ = -0.000476
$\theta_{1m}x_{1m} + \theta_{2m}x_{2m} + \varepsilon'_m$ = 0.000612
$\theta_{1t}x_{1t} + \theta_{2t}x_{2t} + \varepsilon'_t$ = -0.000466
Using R-programming, the values for the coefficients and the associated errors in the equations were found to be as follows:
θ_{1k} = -0.1473, θ_{1m} = -0.2824, θ_{1t} = -0.1680. These are the factors for insecurity for Kangundo Road, Manyanja Road and Thika Road, respectively.
θ_{2k} = 0.0550, θ_{2m} = 0.0920, θ_{2t} = 0.0214. These are the factors for perceived scenery for Kangundo Road, Manyanja Road and Thika road, respectively.

The new values for errors were found to be ε_K' = -0.000074, ε_m' = 0.000476, ε_t' = -0.000392

The results show that incorporating perceived insecurity and perceived scenery in the route assignment reduced the error in the assignment process by 98.4%, 22.2% and 15.8% for Kangundo Road, Manyanja Road and Thika Road, respectively. In addition, the factors for perceived insecurity for the three routes were negative, ranging from -0.1473 to -0.2824, proving that perceived insecurity has a negative effect on the utility of a route.

On the other hand, perceived scenery had positive factors ranging from 0.0214 to 0.0920, showing that an increase in perceived scenery has a positive effect on route choice. From the results, factors for perceived insecurity are much higher compared to factors of perceived scenery and therefore security has a higher effect on a route compared to scenery. Therefore, to increase the route choice for any route, the perception of insecurity on the route must be reduced through aspects such as proper road geometry, signage and markings, well-designed intersections and proper pavement quality.

To develop the route assignment model, the average absolute error of 0.000314, established after incorporating perceived insecurity and perceived scenery, was used to calibrate the model alongside the data measured in the field. The following equations represented the probabilities of selection of the routes.

$$0.385=\frac{e^{(65\theta+14\theta_1+10\theta_2+0.000314)}}{e^{(65\theta+14\theta_1+10\theta_2+0.000314)}+e^{(78\theta+16\theta_1+10\theta_2+0.000314)}+e^{(74\theta+15\theta_1+11\theta_2+0.000314)}}$$

$$0.443=\frac{e^{(78\theta+16\theta_1+10\theta_2+0.000314)}}{e^{(65\theta+14\theta_1+10\theta_2+0.000314)}+e^{(78\theta+16\theta_1+10\theta_2+0.000314)}+e^{(74\theta+15\theta_1+11\theta_2+0.000314)}}$$

$$0.172=\frac{e^{(74\theta+15\theta_1+11\theta_2+0.000314)}}{e^{(65\theta+14\theta_1+10\theta_2+0.000314)}+e^{(78\theta+16\theta_1+10\theta_2+0.000314)}+e^{(74\theta+15\theta_1+11\theta_2+0.000314)}}$$

The nonlinear equations were optimized using the 'optim' technique in the R programme to obtain the values for θ, θ_1 and θ_2 which were found to be:

θ = -0.00401

θ_1 = -0.01982

θ_2= 0.00175

Therefore, the generalized utility equations for any route *i* on the Komarock-Nairobi CBD are as follows:

$U_i = -0.00401t_i - 0.01982I_i + 0.00175s_i + 0.000314$

Where:

t_i= Travel time on a route *i*

I_i= score on perceived insecurity on a route i.

s_i= score on perceived scenery on a route i.

Using the utility function obtained above, the general probability equation for selecting any route (*i-j*) in the Komarock-Nairobi CBD corridor is given in Equation 5.

$$P_r^{ij} = \frac{e^{(-0.00401t_i-0.01982I_i+0.00175s_i+0.000314)}}{\sum_r e^{(-0.00401t_i-0.01982I_i+0.00175s_i+0.000314)}} \quad (5)$$

The utility function U_i incorporates travel time, perceived insecurity and perceived scenery as factors affecting route choice. The negative coefficients for travel time and perceived insecurity imply that higher travel times and higher perceived insecurity decrease the utility of a route, thus making a route less desirable.

The positive coefficient for perceived scenery shows that increased scenery increases the utility of a route, making it more attractive.

The probability equation P_r^{ij} transforms the utilities U_i into probabilities of selecting the route. Routes with higher utilities (lower values of $-0.00401t_i - 0.01982I_i + 0.00175s_i + 0.000314$) will have higher probabilities of being selected by motorists. This probabilistic model captures route selection preferences based on objective (travel time) and subjective (perceived insecurity and perceived scenery) criteria.

4.9. Model Validation

An extra 30% of data was collected for validation of the model. The probability of selection of the routes was calculated using the model and compared with the probability obtained from the field. The results are shown in Table 10.

Table 10. Calculated probability versus measured probability for route selection.

Route	Calculated probability	Measured Probability	% Absolute Error
Kangundo Rd.	0.328	0.368	10.87%
Manyanja Rd.	0.469	0.386	21.5%
Thika Rd.	0.203	0.246	17.48%
Total	1.000	1.000	

The errors observed (ranging from 10.87% to 21.5%) suggest that while the model broadly captures overall probabilities, there are notable discrepancies at the route level. In transportation modeling, accuracies within a 10-20% error range are often considered reasonable, depending on the specific application and stakeholders' tolerance for error. Improvements to this model should aim to enhance reliability.

4.10. Implication and Application

The utility function modelled in this study assigns a higher weight to perceived insecurity (I_i) compared to travel time (t_i). This indicates that in the decision-making process for route selection on the Komarock-Nairobi CBD corridor, perceived insecurity has a stronger influence on the utility of a route than travel time. This can be explained by the fact that perceived insecurity, such as concerns about crime or safety on a route, can significantly impact individuals' route choice behaviour. Even if a route offers shorter travel time, if it is perceived as less safe, individuals may avoid it, opting for longer but safer alternatives. Liu et al. and Loukaitou-Sideris & Fink showed that safety concerns can override other factors in route selection decisions. Additionally, the case of the Komarock-Nairobi CBD corridor may have this variance due to the context and characteristics of the population. In urban environments like Nairobi, where safety concerns might be more prevalent or perceived as more impactful due to higher crime rates or specific incidents, individuals may assign higher importance to perceived insecurity when evaluating route options.

The modified route choice model can be utilized in infrastructure investment prioritization and policy impact assessment. The model provides a tool that can assess the potential impacts of policies such as safety improvements and environmental measures on a route. The model allows for route evaluation from a user-experience perspective. Therefore, planners can focus on improving routes with lower user preference due to insecurity and low scenery scores by prioritizing improvements like landscaping, lighting or security features such as patrol. The model can also quantify the influence of environmental attributes like scenery on route choice, thus providing useful information for sustainable transport corridor planning.

5. Conclusion

Incorporating perceived insecurity and perceived scenery in route choice modelling was shown to increase the accuracy of the modelling process by reducing the randomizing error of routes' utility functions. A 26%-31% reduction in the randomizing error was obtained in this study.

The modified model that incorporates perceived insecurity and perceived scenery provides valuable insights into route preference and can guide decisions on infrastructure investments, safety measures and route promotional strategies. The model contributes to improved accuracy in route choice modelling, which can enhance user satisfaction by aligning transportation services more closely with actual user preferences and behaviours.

The model shows good performance in predicting route selection probabilities. The errors observed are within a range that suggests that the model is usable but should be refined more.

It is recommended that the model adjustments and further validation should be undertaken to address any discrepancies and enhance the model's accuracy and reliability for use in urban transportation planning and management. The efforts should seek to enhance the usability of the model beyond the Komarock-Nairobi CBD Corridor, i.e., replicability.

Areas of Research

Research should be considered to extend the model to consider multiple modes such as buses, walking, and so on along the same corridor.

The model's robustness and transferability to other corridors or cities with similar or different traveller characteristics should be further studied.

References

[1] Xueqin Long et al., "Dynamic Evolution of Traveler's Bounded Rational Route Choice Behaviour," *Journal of Advanced Transportation*, vol. 2018, no. 1, pp. 1-12, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[2] Staffan Algers, Stein Hansen, and Goran Tegner, "Role of Waiting Time, Comfort and Convenience in Modal Choice for Work Trip," *Transportation Research Record*, vol. 534, no. 534, pp. 38-51, 1975. [Google Scholar] [Publisher Link]

[3] Frank S. Koppelman, and Patricia K. Lyon, "Attitudinal Analysis of Work/School Travel," *Transportation Science*, vol. 15, no. 3, pp. 175-293, 1981. [CrossRef] [Google Scholar] [Publisher Link]

[4] Maria Vredin Johansson, Tobias Heldt, and Per Johansson, "The Effects of Attitudes and Personality Traits on Mode Choice," *Transportation Research Part A: Policy and Practice*, vol. 40, no. 6, pp. 507-525, 2006. [CrossRef] [Google Scholar] [Publisher Link]

[5] Mark Beecroft, and Kate Pangbourne, "Future Prospects for Personal Security in Travel by Public Transport," *Transportation Planning and Technology*, vol. 38, no. 1, pp. 131-148, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[6] Mohamed Abdel-Aty, and Yile Huang, "Exploratory Spatial Analysis of Expressway Ramps and its Effects on Route Choice," *Journal of Transportation Engineering*, vol. 130, no. 1, pp. 104-112, 2004. [CrossRef] [Google Scholar] [Publisher Link]

[7] Gila Albert, Tomer Toledo, and Uri Ben-Zion, "The Role of Personality Factors in Repeated Route Choice Behavior: Behavioral Economics Perspective," *European Transport*, vol. 48, pp. 47-59, 2011. [Google Scholar] [Publisher Link]

[8] Carlo Giacomo Prato, Shlomo Bekhor, and Cristina Pronello, “Latent Variables and Route Choice Behavior,” *Journal of Transportation*, vol. 39, pp. 299-319, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[9] Sigal Kaplan, and Carlo Giacomo Prato, “Closing the Gap between Behavior and Models in Route Choice: The Role of Spatiotemporal Constraints and Latent Traits in Choice Set Formation,” *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 15, no. 1, pp. 9-24, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[10] Sergio A. Velastin et al., “A Distributed Surveillance System for Improving Security in Public Transport Networks,” *Measurement and Control*, vol. 35, no. 7, pp. 1-5, 2002. [CrossRef] [Google Scholar] [Publisher Link]

[11] Trond Nordfjærn, and Torbjørn Rundmo, “Transport Risk Evaluations Associated with Past Exposure to Adverse Security Events in Public Transport,” *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 53, pp. 14-23, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[12] Meng Li, Hai-Jun Huang, and Henry X. Liu, “Stochastic Route Choice Equilibrium Assignment for Travelers with Heterogeneous Regret Aversions,” *Journal of Management Science and Engineering*, vol. 3, no. 1, pp. 1-15, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[13] William Gemmell Cochran, “Sampling Techniques,” *John Wiley and Sons*, pp. 1-428, 1977. [Google Scholar] [Publisher Link]

[14] M. Zuckerman, S.B. Eysenck, and H.J. Eysenck, “Sensation Seeking in England and America: Cross-Cultural, Age, and Sex Comparisons,” *Journal of Consulting and Clinical Psychology*, vol. 46, no. 1, pp. 139-149, 1978. [CrossRef] [Google Scholar] [Publisher Link]

[15] Mary Hegarty et al., “Development of a Self-Report Measure of Environmental Spatial Ability,” *Intelligence*, vol. 30, no. 5, pp. 425-447, 2002. [CrossRef] [Google Scholar] [Publisher Link]

[16] R. Likert, “A Technique for the Measurement of Attitudes,” *Archives of Psychology*, vol. 22, no. 140, 1932. [Google Scholar] [Publisher Link]

[17] Xinjun Lai et al., “Understanding Drivers' Route Choice Behaviours in the Urban Network with Machine Learning Models,” *IET Intelligent Transport Systems*, vol. 13, no. 3, pp. 427-434, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[18] Humberto González Ramírez et al., “Travel Time and Bounded Rationality in Travellers’ Route Choice Behaviour: A Computer Route Choice Experiment,” *Travel Behaviour and Society*, vol. 22, pp. 59-83, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[19] Y. Shiftan, S. Bekhor, and G. Albert, “Route Choice Behavior with Pre-Trip Travel Time Information,” *IET Intelligent Transport Systems*, vol. 5, no. 3, pp. 183-189, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[20] Nandita Basu et al., “What do Pedestrians Consider when Choosing a Route? The Role of Safety, Security, and Attractiveness Perceptions and the Built Environment during Day and Night Walking,” *Cities*, vol. 143, pp. 1-14, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[21] Francisco Alonso et al., “Assessing Risky and Protective Behaviors among Pedestrians in the Dominican Republic: New Evidence about Pedestrian Safety in the Caribbean,” *Journal of Transport and Health*, vol. 22, pp. 1-14, 2021. [CrossRef] [Google Scholar] [Publisher Link]