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Analyzing Passengers' Mode Choice Behavior in an Integrated Urban Transport System: Application to BRT System at Ring Road in Greater Cairo

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Abstract.

Egypt is actively pursuing sustainable urban mobility through the maximization of mass transit and the implementation of Transit-Oriented Development (TOD). In Greater Cairo, the planned BRT system on the Ring Road represents a significant stride towards achieving these goals. While the BRT forms the backbone, its effectiveness within the broader integrated urban transport system is enhanced by seamless linkages and safe transfers with active mobility modes, specifically Non-Motorized Transport (NMT). This paper employs the Logit calibration of advanced discrete choice models, a robust method for analyzing individual decision-making, to predict passengers' mode choice behavior. Data was collected from individuals across all relevant Ring Road zones in Greater Cairo using a carefully designed Stated Preference (SP) survey, which captured their responses to hypothetical travel scenarios. The empirical findings indicate that socioeconomic factors, particularly income, are powerful determinants of mode choice, with higher-income individuals showing a greater propensity to use private vehicles. However, aligned with trends in developing nations, attributes directly related to service quality and accessibility, such as in-vehicle time, were found to exert a notably greater impact on commuters' mode preferences for public transport options like the BRT.

Keywords: Mode Choice, Bus Rapid Transit, Ring Road of Cairo, Public Transportation.

1 Introduction

1.1 An Overview

Egypt, the most populous nation in the Middle East and North Africa, is predicted to have a population of 160 million by 2050, with the Greater Cairo Region (GCR) serving as the economic, industrial, and cultural center. With a population of 24 million, The GCR links 551 different built-up regions within a 120-kilometer radius to avoid the Nile Basin and historic metropolitan centers. Caused by the dry environment and 97% reliance on the Nile River for water supplies (Elmahdy et al., 2022).

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1.2 Greater Cairo Region (GCR)

Cairo is a large metropolis with over 10 million inhabitants, facing significant transportation challenges. The public transit system, serving 25% of the Greater Cairo Region (GCR), is overloaded and unreliable, contributing to traffic congestion and safety concerns. While the government aims to improve this by introducing privately owned vehicles and enhancing infrastructure, the road system, which also accounts for 25% of the GCR, is inadequate due to bad driving habits, low car occupancy, traffic, and parking shortages.

Traffic volume on main roads in GCR ranges from 2,000 to 7,000 vehicles per hour, resulting in very low average travel speeds, often less than 10 km/h and even dropping to 5-6 km/h during rush hour (World Bank, 2014). This significantly impacts the quality of life and economic activity. Consequently, the Egyptian government is actively working on planning and developing the road network and transportation system in Greater Cairo.

The development of transportation infrastructure is highlighted as crucial for economic prosperity, facilitating the movement of goods and people. The text also provides statistics on licensed vehicles in Egypt, showing a decrease from 2019 to 2022. In 2024, the total number of licensed automobiles in the Republic governorates was 9.9 million, with private cars accounting for the majority (5.5 million). (CAMPAS, 2024).

1.3 Ring Road Corridor

The Cairo Ring Road is a major highway in the Greater Cairo metropolitan area, encircling large urban centers in the governorates of Cairo, Qalyubia, and Giza. Its construction began in the late 1980s and the final section was completed in the 2000s. This road is a highly strategic transportation axis in Greater Cairo. It provides new access to densely populated areas, including informal districts located north, south, and west of Cairo, such as Al-Marg, Shubra, Bulaq al Dakrur, and Dar al-Salam. Furthermore, the Ring Road facilitates connections between suburban areas through numerous bus routes and links major transportation infrastructure in Greater Cairo, including the airport, existing and future metro lines, and other main roads.

1.4 Current situation

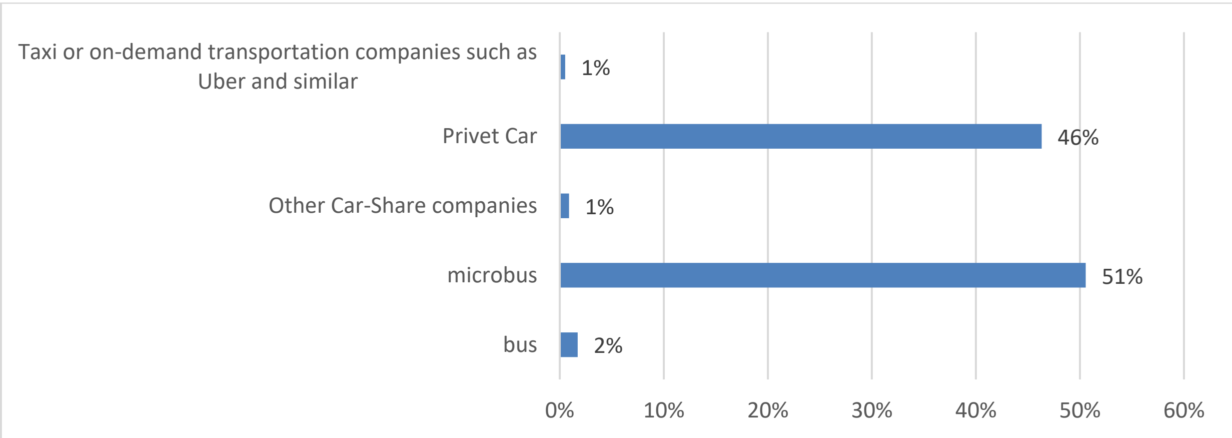

Fig. 1. Current transportation means on the Ring Road

Current transportation patterns on the Ring Road in Greater Cairo reveal a significant reliance on microbuses, which constitute the dominant mode of transport with over half of surveyed individuals (51%), followed by a substantial use of private cars (46%). Other options like buses, car-sharing, and on-demand platforms represent a small fraction of usage on this major artery. This existing landscape of mode choice, where cost-effective but potentially time-consuming public transit like buses contrasts with the quicker but more expensive private vehicles and the convenience-focused ride-hailing services, provides crucial context for evaluating the potential role and effectiveness of the proposed BRT system discussed in subsequent analyses.

1.5 Problems Definition and Objectives

The public transportation in Cairo is facing significant challenges, leading to it being described as "poor." One major problem is that people heavily depend on their cars and taxis. There aren't enough large-scale public transportation options available, like dedicated bus rapid transit systems (BRT) that have their own lanes for faster travel, or convenient car-sharing programs that could reduce the number of individual vehicles on the road.

The goal of this study is to calibrate a logit mode choice model using data from an online survey in Egypt's Greater Cairo Region (GCR), specifically:

(1) Design a stated preference survey for users in GCR to measure their willingness to pay and their preference for the new BRT line
(2) Study the current people's mode choice behaviour in (GCR)
(3) Develop a mode choice model that reflects the captured behaviour and formed as a combined revealed and stated preference
(4) Identify the study area for the BRT line based on the Origin destinations captured in the survey

2 Literature Review

2.1 Empirical Mode Choice Model

The choice of transport mode is crucial in transport planning and policymaking. Discrete choice models are used to understand mode choice relationships, although the accuracy of prediction can be limited (Ben-Akiva and Lerman, 1985).

Factors Affecting Mode Choice Behavior

The choice of transport mode is influenced by a variety of factors, including journey time, cost, waiting time, ease of transfers, comfort, socioeconomic traits, land use, accessibility, service quality and tour complexity (Frank et al., 2008). Furthermore, the Value of Travel Time (VOT) is important for cost-benefit analysis and congestion pricing (Koppeleman and Bhat, 2006). Notably, VOT varies for work and non-work trips.

Aggregate and Disaggregate Mode Choice Models

Aggregate models represent the average behavior of traveler groups (e.g., trip-end, trip-interchange). While potentially accurate, they are harder to implement and criticized for rigidity.

Disaggregate models, introduced in the 1980s, represent individual behavior, adapting to personal characteristics and options. They are better for policy analysis (more causal and adaptable) and more dependable per data cost than aggregate models (Darwish et al., 2024).

Statistical Mode Choice Models

Statistical mode choice models are crucial for understanding travel behavior. Discriminant models classify choices and predict group membership, as demonstrated by Zenina and Borisov (2011).

Discrete choice models, particularly Logit, Probit, and General Extreme Value (GEV) models, are widely used in transportation due to their ability to represent complex travel patterns.

The Multinomial Logit (MNL) model, a basic GEV model, assumes independent utilities and homogeneous responsiveness, including the IIA property. Factors like travel time, cost, and demographics influence mode choice, as shown in studies by Sekhar (2014) and Ahmadi (2006). Binary logit models, like the one used by Abuhamoud et al. (2011) in Libya, highlight the importance of considering factors like gender in transportation planning.

Nested Logit (NL) models address some limitations of MNL by first calculating choice proportions within subgroups before estimating proportions between main choices. Utilizing a Type I extreme value distribution, NL models offer a balance between complexity and computational ease, helping determine the optimal structure of choices, as exemplified by Abdel-Aty and Abdelwahab (2001) and Khan (2007).

The Multinomial Probit (MNP) model, while a popular alternative to GEV models, involves high computational costs and assumes a normal distribution for random taste heterogeneity, potentially limiting flexibility and interpretation. While MNP allows for taste variation and repeated choices (Sekhar, 2014), studies like Can (2013) show its application in specific contexts like tourist mode choice. However, research by (Ghareib, 1996) and (Bhat and Sardesai, 2006) suggest that while probit models may offer better goodness-of-fit in some cases, logit models can be superior for estimating travel behavior, and the flexibility of probit models can lead to interpretation and precision issues.
In essence, the choice of mode choice model depends on the specific research question, data characteristics, and the trade-off between model complexity, computational feasibility, and interpretability of results.

2.2 Development of Mode Choice Models

In discrete choice modeling, utility represents the value or appeal of an option to a decision-maker, who selects one option from a limited set. The principle of utility maximization suggests that individuals choose the alternative that provides them with the highest utility (Khan, 2007).
While deterministic utility models assume perfect rationality and disregard individual preferences, leading to potential inaccuracies due to incomplete information or analyst limitations, probabilistic choice theory or the Random Utility Model accounts for decision-making errors. It breaks down utility into a predictable component (estimated by the analyst) and an uncertain component (representing individual variations) (Darwish et al., 2024).
Logit models, based on utility maximization theory (Ben-A kiva and Lerman, 1985), are categorized into three types: multinomial logit (using chooser-specific data), conditional logit (using choice-specific data with identical coefficients), and mixed logit (incorporating both types of data and coefficients). These models are fundamental for understanding and implementing decision-making processes.
The probability that an individual will choose a particular transport mode is calculated using a formula that considers the utility of that mode relative to the utility of all other available modes in the choice set (Sekhar, 2014). Logit models can be further classified into binary, multinomial, and nested logit models.

2.3 Cairo's BRT

In order to improve urban mobility and ease traffic, Egypt is putting in place a Bus Rapid Transit (BRT) system on the Cairo Ring Road (CRR). Construction is anticipated to begin concurrently with the CRR's expansion to seven lanes (excluding the Mounib bridge) (S. Ibrahim, 2021). The initiative intends to enhance infrastructure and reduce travel times.

The Bus Rapid Transit (BRT) system will provide high-quality, effective services with an intelligent transport system (ITS) and is renowned for its flexibility and cost-effectiveness with dedicated lanes (Cervero, 2013).
Greater Cairo's accessibility and connectivity are intended to be enhanced by the Cairo BRT. In an effort to minimize pollution and enhance traffic flow, the General Authority for Roads, Bridges & Land Transport (GARBLT) would restrict heavy truck hours and outlaw microbuses in order to promote the BRT. Ridership has increased in similar BRT systems, as the one in Hubli-Dharwad, India (GUPTA, 2020). Although there are still questions over how these rules would affect private vehicle use in the long run, data on commuter satisfaction and service quality will be gathered in order to assess the project's effectiveness using regional and community performance methodologies. Multimodal integration and giving non-motorized transportation priority are two possible enhancements (S. Ibrahim, 2021). Local demand as well as vehicle and station capacity will be taken into consideration when evaluating BRT performance (Mohamed et al., 2022).

3 Methodology and Data Collection

The text discusses data collection methods for transportation modeling, highlighting the importance of surveys such as household, workplace, destination, and intercept surveys. While sampling is crucial, the traditional paper and pencil interviewing (PAPI) method has higher error rates compared to Computer Assisted Interviewing (CAPI) (Kalfs, 1995). Online surveys are increasingly becoming a vital research tool across various domains. Studies by Adler et al. (2002) have shown that web-based trip surveys are highly capable of handling complex preference studies.
In the context of the user's research, an online questionnaire was utilized to gather data from ring road users and individuals using different modes of transportation, both public and private. This questionnaire targeted people of all categories and ages to collect a large and credible dataset. The aim is to analyze this data to understand the opinions of ring road travelers regarding the usability of the Bus Rapid Transit (BRT) system.

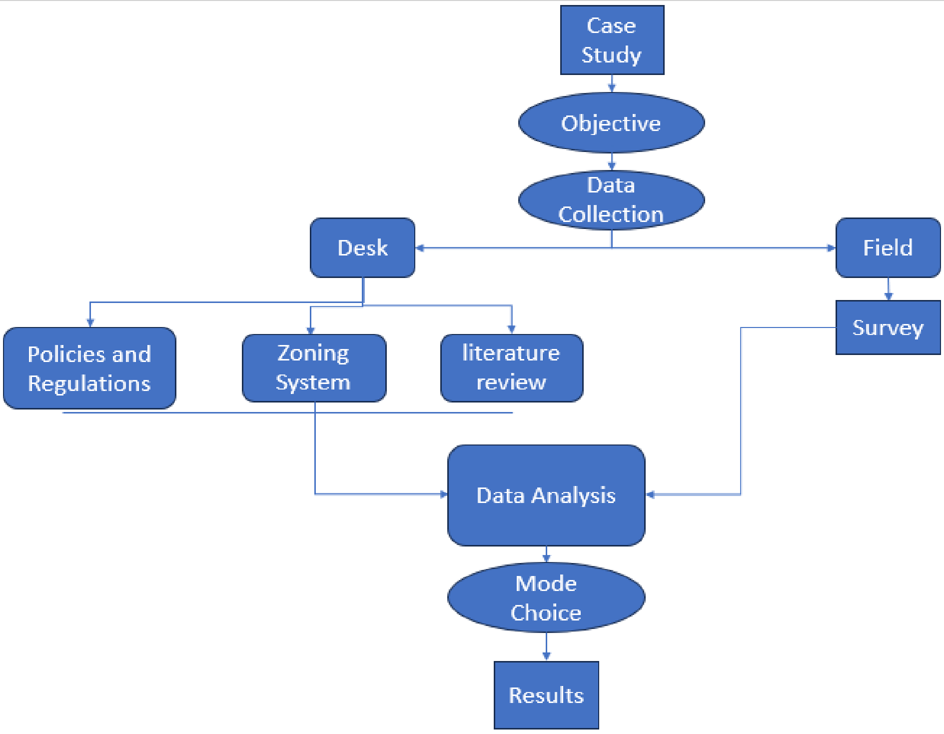

Chart 1. Methodology of Research

3.1 Survey design

Each participant provided a variety of information about their last trip, including:
• Last Trip information (Revealed Preference (RP) data).
• Stated Preference (SP) data utilizing variable levels based on the RP data
• Choice set Preferences.
• Sociodemographic information.

The text discusses two types of data used in transportation research: Revealed Preference (RP) data, which accurately reflects current travel patterns and prices, and Stated Preference (SP) data, whose reliability has been questioned. The data fusion approach, introduced by Ben-Akiva and Morikawa (1990b), combines complementary data sources like RP and SP. Despite concerns about bias, SP data offers valuable insights into the trade-offs people make between different transportation attributes.
The analysis in this research focuses on SP variables such as connection insurance/combined ticketing, transfer or waiting times, and the valuation of standard factors like travel cost, in-vehicle travel time, access/egress time, and socioeconomic variables. Specifically, the research investigates the impact of time, cost, and frequency of various transportation options to understand travelers' preferred choices and whether the Bus Rapid Transit (BRT) system can attract them away from their current modes of transport.

3.2 Sample Size

According to the Central Agency for Public Mobilization and Statistics (CAPMS, 2025), the population of Cairo exceeds 10 million, Giza Governorate has over 9 million residents, and Qalyubia Governorate has more than 6 million people. This study was conducted in the Greater Cairo Region, which has a total population of 25 million, and it utilized primary data. The Slovin algorithm was employed to determine a sample size of at least 100 responders, using Cairo's total population (N) and an error rate (e) of 10%. The study successfully collected 118 questionnaires from ring road users, thus fulfilling the sample size requirement.
Westendorp's 1976 Pricing Model, also known as the Price Sensitivity Meter (PSM), is a technique used by marketers to determine customer value and assess the effects of price adjustments, aiming to identify declining consumer interest.

$$S = \frac{N}{1 + N(e)^2}$$

• S: The sample size
• e: Represents the percentage of the maximum allowable mistake, which is 10%.
• N: The total population.

Table1. Descriptive of the obtained samples.

Criterion	Category	Regularity	Approximate Percentage (%)
Age	<20	7	5.9
	20–30	75	63.6
	31–40	26	22
	41–50	9	7.6
	51–60	1	0.8
	> 60	0	0
Gender	Male	214	64

	Female	120	36
Trip Purpose	Work	37	31.3
	Education	26	22.3
	Travel	8	7.1
	Visits	46	39.3
Car Ownership		70	59.6
Trip Frequency	Every working day	47	39.8
	Once-Twice a week	26	22.1
	Monthly	21	17.7
	Holidays and occasions	24	20.4
Chosen Mode	Private Car	32	27.27
	Microbus	76	64.5
	Bus	3	2.2
	Mini bus	2	1.7
	Shared Taxi	4	3.25
	Other transport companies (Shared bus)	1	1.08
Total		**118**	**100%**

The data suggests the typical respondent is a young (20-30 years old), male (64%), likely a daily commuter (39.8%) who uses a microbus (64.5%) for trips related to visits or work. A substantial portion of respondents own cars (59.6%), but still primarily use microbuses. This suggests potential factors influencing mode choice beyond car availability, such as cost, convenience, or accessibility of microbus services. Further investigation is needed to understand the reasons behind the microbus preference.
After surveying the opinions of the ring road users, it became clear that the most used means of transportation are private cars in the lead and the microbus (carpooling). Thus, a comparison was made between these means and the new BRT to determine whether the ring road users would be willing to use it and leave the other means as shown in table 1.

The samples obtained from the expressed preference survey are examined in order to determine the average trip characteristics. In order to determine the qualities of the options that were not chosen, these average trip parameters are essential. the travel time (in minutes), the average traveling time (in minutes), and the travel cost (in Egyptian Pounds, or "EGP") Because it is widely accessible and reasonably priced for a moderate journey time, the unofficial shared taxi has emerged as Cairo's most popular means of transportation. Because of its high fare, the shortest journey distance and time are for taxi mode. Even while public transportation has a longer average trip time than other modes, it nevertheless has the lowest cost of transportation, showing that most public transport users are not from the high-income level category

4 Multinomial Logit model development

4.1 Model Calibration

A preliminary model including all variables was calibrated to identify significant attributes. After excluding non-significant qualities, the utility function considered mode-specific constants for taxi, public transport, and informal shared taxi; in-vehicle travel time (IVTT); out-of-vehicle travel time (OVTT); and travel cost (TC). The private vehicle was the reference mode. Time and cost parameters are expected to be negative. The dataset was split into 85% for calibration and 15% for validation. The calibration process was conducted using Biogeme software (Bierlaire, 2016), which requires a model specification and a data file containing both chosen and non-selected options. Options for trip cost, travel duration, and service availability are included in Table 2. Based on traveling distance, the features of non-chosen alternatives were estimated using travel duration, frequency, and cost.

The prophetic ability of the calibrated model is computed based on the estimated parameters. The serviceability associated with the seven modes of transportation is computed for the testing set of the entire sample. Every method of transportation's likelihood of selection is also determined, and the mode with the highest probability is referred to as the designated bone. The bone that was initially selected is also used to change the selected mode. Private vehicle, hack, microbus, shared bus, minibus, and informal participated hack are the seven alternatives from which the marker (transport mode) is designated in the transport mode choice model. The model is built as a bracket problem with multiple classes. The machine literacy model is calibrated using the Biogeme operation.

Table 2. MNL model parameters.

Parameters	Nature	Expected Sign
In-vehicle travel time (βIVTT)	Value	Negative
Frequency of vehicle (βFREQ)	Value	Positive
Total Travel Cost (βTC)	Value	Negative
Car Constant (ASC_Car)	Value	Negative or Positive
BRT Constant (ASC_BRT)	Value	Negative or Positive
Microbus Constant (ASC_Microbus)	Value	Negative or Positive
Bus Constant (ASC_Bus)	Value	Negative or Positive
Minibus Constant (ASC_Minibus)	Value	Negative or Positive
Sharedbus Constant (SC_Sharedbus)	Value	Negative or Positive
SharedCar&Taxi Constant (ASC4)	Value	Negative or Positive

Checking coefficients signs

As shown at table3 the model suggests that the frequency of vehicles and the total travel cost are statistically significant factors influencing mode choice. There are also significant inherent preferences (captured by the ASCs) for different modes. Notably, Sharedbus and SharedCar&Taxi have strong negative preferences associated with them, while Car, BRT, Microbus, Bus, and Minibus have positive preferences. The in-vehicle travel time, while having the expected negative sign, is not statistically significant in this particular model. The goodness-of-fit statistics indicate that the model as a whole performs reasonably well in explaining the observed mode choices.

t-statistic

The t-statistic values for all parameters are more than ± 1.96, indicating that all coefficients are statistically significant at the 5% level of significance.

P-value

Given that the P-value values for each parameter are less than 0.05, all coefficients are determined to be statistically significant a
t the 5% level of significance.

Goodness of fit measures

Measures of goodness of fit are employed to compare various utility function specifications. As table 3 A specification is deemed superior if all other factors remain the same and the highest value of the likelihood function is higher. As table.3 the value of the likelihood ratio index (ρ^2) is 0.452 while the adjusted likelihood ratio index ($\tilde{\rho}^2$) is 0.441 and these values are considered satisfactory.

Table 3. COEFFICIENTS VALUES OF THE CALIBRATED MODEL.

Parameters	Value	Standard error	t-test	p-value
In-vehicle travel time (βIVTT)	-0.00347	0.00335	-1.04	0.30
Frequency of vehicle (βFREQ)	0.00617	0.00193	3.19	0. 00
Total Travel Cost (βTC)	-0.00532	0.00268	-1.99	0.05
Car Constant (ASC_Car)	3.36	0.354	9.27	0. 00
BRT Constant (ASC_BRT)	3.07	0.335	8.24	0.00
Microbus Constant (ASC_Microbus)	3.07	0.327	8.95	
Bus Constant (ASC_Bus)	1.82	0.365	4.91	0.00
Minibus Constant (ASC_Minibus)	1.00	Fixed		
Sharedbus Constant (ASC_Sharedbus)	-9.66	0.194	-49.70	0.00
SharedCar&Taxi Constant (ASC_SharedCar)	-9.83	0.212	-46.37	0.00
Null log-likelihood:	-840.127			
Initial log-likelihood:	-983.323			
Final log-likelihood:	-460.669			
Likelihood ratio test:	758.915			
Rho-square:	0.452			
Adjusted rho-square:	0.441			

5 Results and discussion

5.1 Sensitivity Analysis

Sensitivity in mode choice models measures how the probability of selecting a specific transportation mode changes in response to variations in its attributes. This can be quantified using the Direct Elasticity test (Koppelman et al., 2006), which calculates the percentage change in the likelihood of choosing a mode due to a percentage change in a related variable. Unlike some machine learning models, sensitivity analysis provides valuable statistical interpretation. In this research, sensitivity analysis is applied to the calibrated and validated Cairo MNL model to estimate the effects of different policies on the share of transport modes and to determine the percentage of travelers who might switch to public transport. This involves examining a "do-nothing" scenario to understand the impact of current public transport availability on Cairo's modal split and exploring various scenarios to assess potential BRT usage. When complete data is unavailable, an aggregate model is used, assuming the availability of all transportation modes and applying average travel time and cost for each within the MNL utility function.

Several different scenarios were used, as follows:

A. Scenario 1: Mode Choice Behavior After BRT Implementation
B. Scenario 2: Impact of increased fuel prices
C. Scenario 3: Increased cost and reduced waiting time
D. Scenario 4: Increased cost and reduced time
E. Scenario 5: Some polices to prevent microbuses

Before going into the different scenarios, we present a summary of the contrast on the current situation on the Ring Road and the travelers’ choice of different means of transportation.

Scenario 1: Mode Choice Behavior After BRT Implementation

The introduction of the BRT system on the Ring Road in Greater Cairo appears to have positively influenced passengers' mode choice behavior. The data indicates a notable shift away from microbuses (decreasing from 51% to 42%) and private cars (decreasing from 46% to 34%), with the BRT capturing a significant 15% share of the market. This suggests that the BRT is successfully attracting passengers who previously relied on less formal or private transportation options, indicating its potential to improve public transport utilization and potentially alleviate traffic congestion in the area. The shares of conventional buses and on-demand transportation services have slightly increased, while minibuses appear as a new category with a small share. Overall, this initial scenario demonstrates a positive impact of the BRT system on the transportation landscape of the Ring Road.

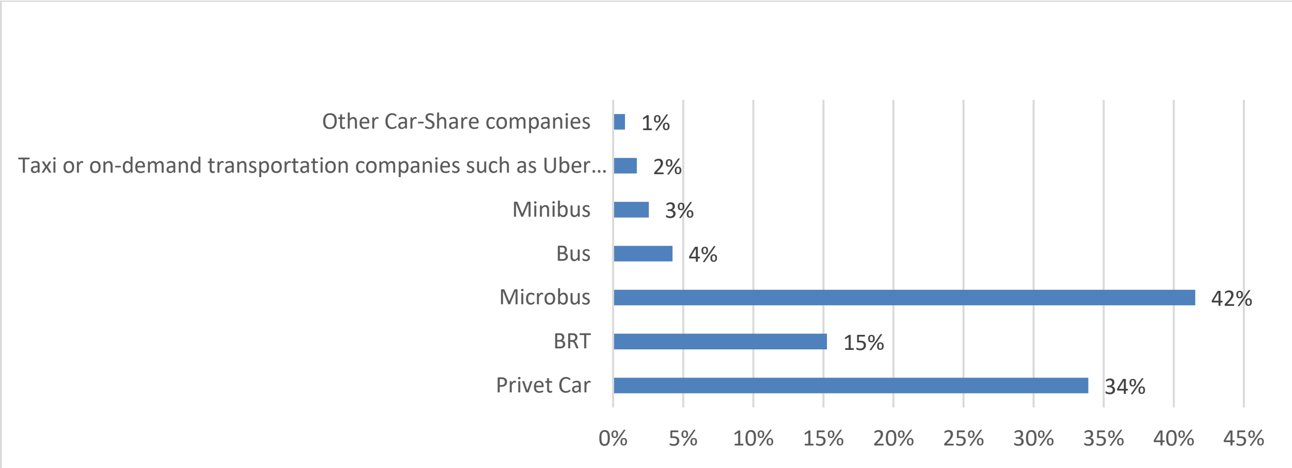

Fig. 2. Mode Choice Behavior After BRT Implementation

Scenario 2: Impact of increased fuel prices

Figure 3 illustrates the response to a scenario where fuel prices increased by 20% while public transportation costs remained constant. The data reveals that a significant majority (92%) of respondents indicated they would not switch to public transportation despite the fuel price hike. Conversely, only 26% of respondents stated they would be inclined to use public transport under these conditions. This suggests a limited elasticity of demand for public transportation in response to fuel price changes within the surveyed population.

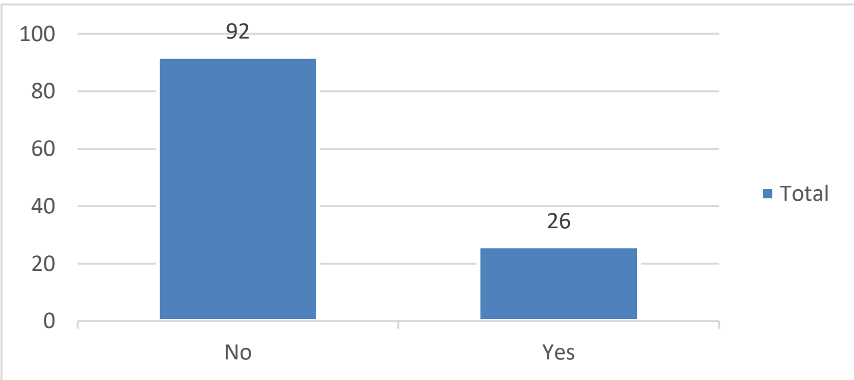

Fig.3 [Fuel prices increased by 20% while the price of public transportation remained constant]

Figure 4 presents a scenario where fuel prices experienced a substantial increase of 50%, coupled with a 10% rise in public transportation fares. In contrast to the previous scenario with a smaller fuel price increase, this situation led to a notable shift in stated preferences. The data indicates that a larger proportion of respondents (76%) reported they would switch to public transportation under these conditions. However, a significant segment (42%) still indicated they would not change their mode of transport. This suggests that a more significant increase in fuel costs, even when accompanied by a smaller rise in public transport fares, has a more pronounced impact on the willingness of individuals to consider public transportation as an alternative.

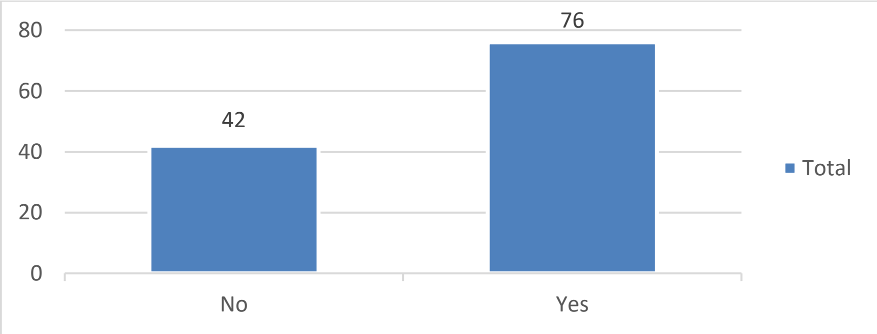

Fig.4 [Fuel prices increased by 50% with a 10% increase in public transportation prices]

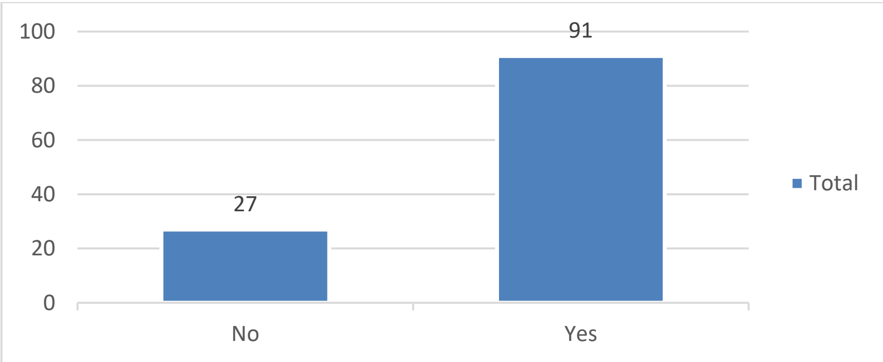

Fig.5 [Fuel prices increased by 70% with public transportation prices rising by 30%]

Figure 5 explores a scenario with a significant 70% increase in fuel prices, accompanied by a substantial 30% rise in public transportation fares. Under these conditions, the data indicates a strong inclination towards switching to public transport, with 91% of respondents stating they would do so. Conversely, only 27% indicated they would not change their mode of transport. This scenario highlights that when the cost of private vehicle usage becomes considerably high, even with a notable increase in public transport fares, a very large majority of individuals are willing to shift towards public transportation options.

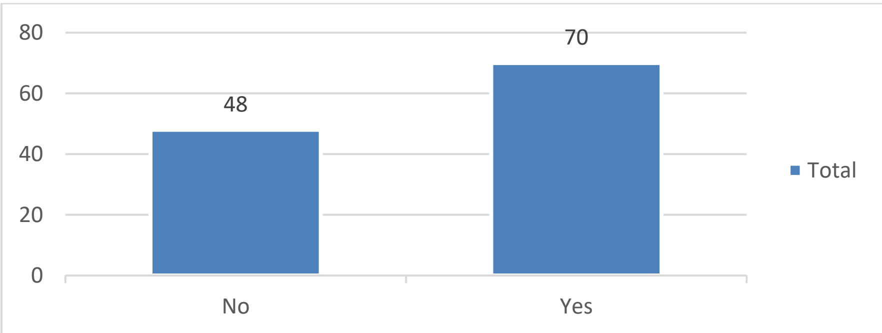

Fig.6 [Fuel prices increased by 80% with a 50% increase in public transportation prices]

Figure 6 presents the most extreme scenario, where fuel prices are assumed to increase by 80% and public transportation fares rise by 50%. In this case, a majority (70%) of respondents indicated they would switch to public transportation. However, a significant portion (48%) still stated they would not change their mode of transport, even with these substantial price increases.

This series of scenarios suggests that while increasing fuel prices act as a strong motivator for considering public transportation, the simultaneous increase in public transport fares can moderate this effect. The tipping point where a large majority is willing to switch appears to occur when the relative cost difference between private and public transport becomes sufficiently significant, even if public transport costs also increase. However, extremely high increases in both might see some resistance remaining, potentially due to factors beyond just price, such as convenience or perceived comfort.

Scenario 3: Increased cost and reduced waiting time

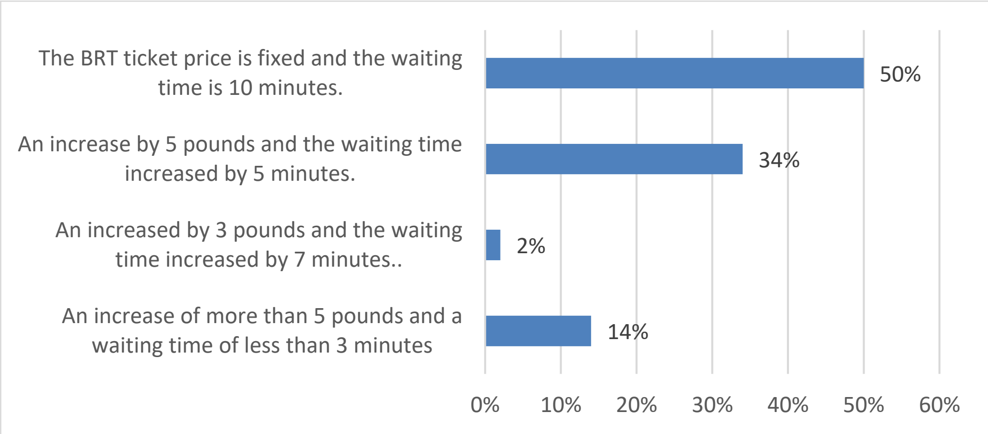

Fig.7 [Increased cost and reduced waiting time]

This bar chart presents the findings of a survey conducted in Egypt to understand commuters' preferences regarding different pricing and waiting time scenarios for the BRT (Bus Rapid Transit) system. The survey question asked: "What do you prefer from the following suggestions?".The data suggests a strong preference among commuters in Egypt for maintaining the existing BRT ticket price, even if it results in a longer waiting time. While a significant portion of respondents are willing to accept a moderate price increase (5 EGP) for a noticeable reduction in waiting time, the resistance to any price increase is evident. The option with the smallest price increase and a relatively longer waiting time was the least favored. This indicates that price sensitivity plays a crucial role in commuters' choices regarding public transportation, potentially outweighing the desire for reduced waiting times, especially for larger price increases.

Scenario 4: Increased cost and reduced time

Figure 8 illustrates Scenario 4, which examines the impact of increased BRT ticket costs and reduced travel times on passenger mode choice. The chart presents four different conditions:

- When the BRT ticket price increased by more than 25 Egyptian pounds and the travel time was reduced by 20 minutes or more, only 3% of respondents indicated they would choose the BRT.
- With a ticket price increase ranging from 20 to 25 Egyptian pounds and a travel time reduction of 15 minutes, the preference for BRT increased to 15%.
- A ticket price increase between 15 and 20 Egyptian pounds, combined with a travel time reduction of 10 minutes, resulted in a significantly higher preference for BRT at 48%.
- The highest preference for BRT, at 52%, was observed when the ticket price increased between 10 and 15 Egyptian pounds, and the average travel time was within the range of 10 to 15 hours (Note: This likely refers to the total average travel time with the BRT, not necessarily a reduction of that magnitude).

This scenario emphasizes the significant role of travel time reduction in attracting passengers to the BRT system, even with increased costs. While substantial cost increases coupled with significant time savings see limited adoption, a more moderate increase in cost combined with a noticeable reduction in travel time can make the BRT a more attractive option for a larger segment of the population. The most preferred condition appears to be a balance between a reasonable cost increase and a competitive overall travel time."

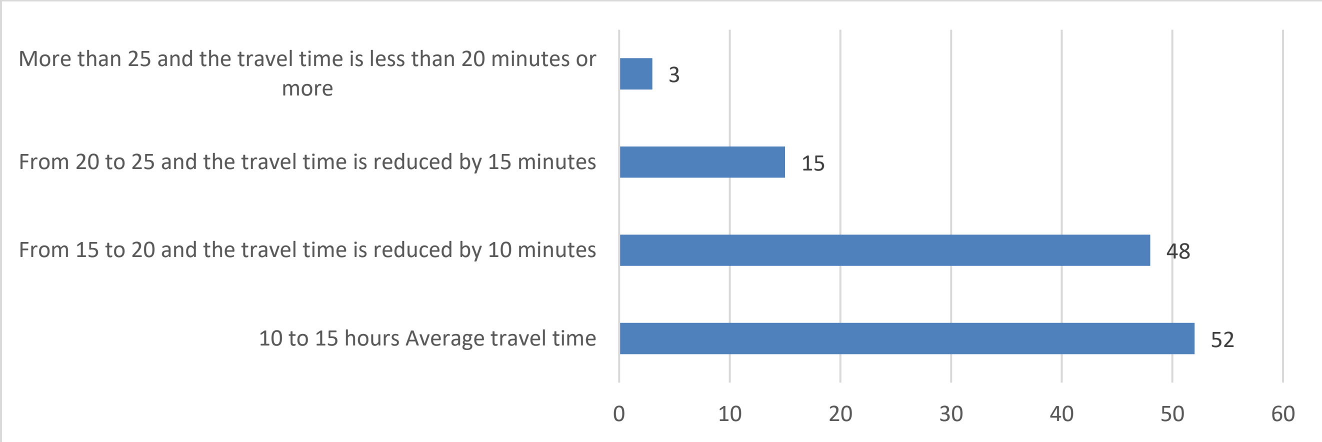

Fig.8 [Increased cost and reduced time]

Scenario 5: Some polices for implementing BRT

The bar chart illustrates the perceived effectiveness of the BRT system as an alternative on the Ring Road under various scenarios. The highest agreement (76%) was for the scenario where microbuses are permanently banned from the Ring Road, suggesting that eliminating direct competition is seen as a strong factor for BRT's effectiveness. Scenarios with relatively high agreement included the presence of slower and cheaper alternative routes (67%), the existence of more expensive but direct private company services like Swvl (65%), and creating a side road for microbuses (52%). A moderate level of agreement was observed when bus prices remained stable while microbus prices increased (41%). Conversely, the lowest perceived effectiveness was in the scenario where both buses and microbuses operate on the Ring Road (23%), and when minibuses are available on the Ring Road at the same price (32%). Overall, the data indicates that the perceived effectiveness of BRT on the Ring Road is significantly influenced by the competitive environment and the availability of alternative transportation options. Reducing or removing competition from microbuses appears to be a key factor for enhancing the perceived success of the BRT system.

The data presented in Fig.9 provides valuable insights into the factors influencing the perceived effectiveness of the BRT system on the Ring Road in Egypt. The findings highlight the significant impact of competition, pricing strategies of alternative transport modes, traffic management policies, and the trade-off between travel time and cost on commuters' perceptions of BRT's effectiveness. Notably, reducing or eliminating competition from microbuses appears to be the most influential factor in enhancing the perceived effectiveness of the BRT system.

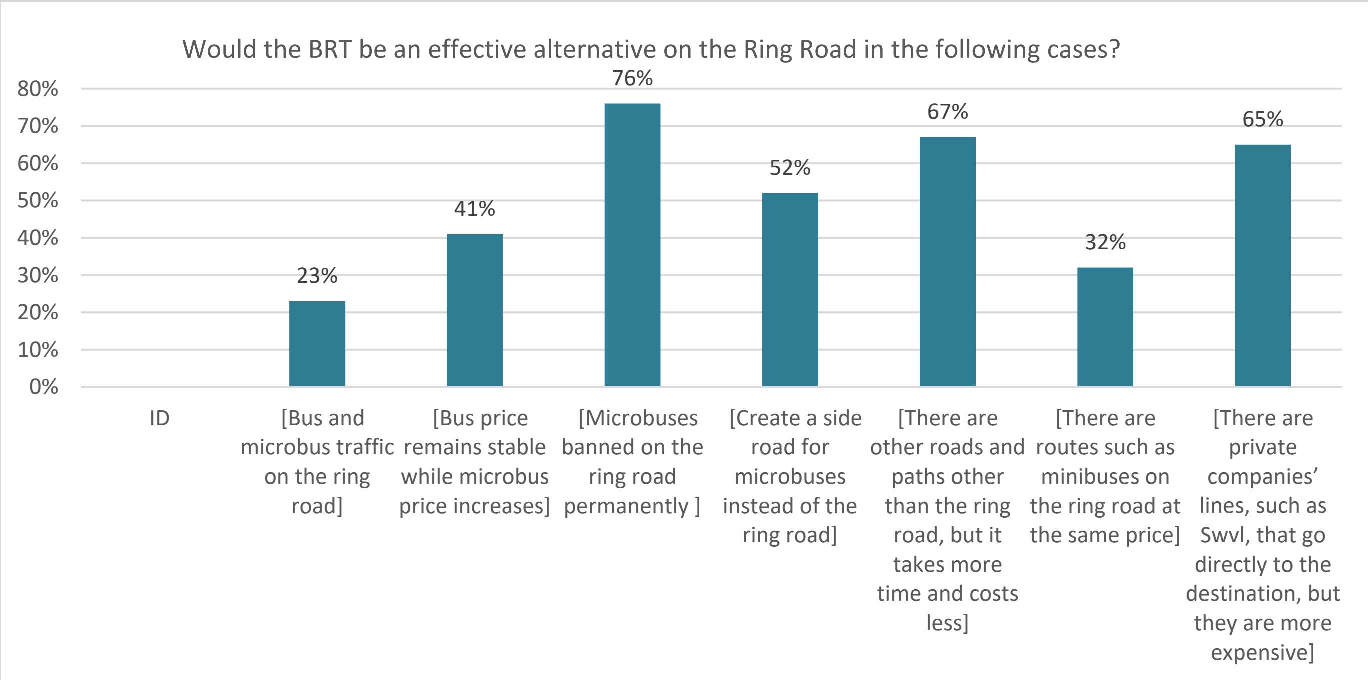

Fig.9 Different scenarios of implementing BRT as a transportation solution on the Ring Road.

5.2 Model Validation

The mode choice model predicts a 3% ridership for the BRT at a 30 EGP ticket price, assuming a travel time reduction of at least 20 minutes. This prediction is lower than the 9.2% willingness to pay observed in Elmahdy et al. (2022) for a similar price (30 EGP) and travel time saving (25 minutes). This discrepancy, alongside the previously noted lower willingness to pay for waiting time reduction in the current study (34% vs. 56.6% for a 5 EGP increase and 5-minute reduction), suggests potential differences in the surveyed populations or the context of the studies. Factors such as varying socio-demographics, data collection timing, model specification, and perceived travel time reductions could contribute to these differences. This comparison highlights the need for further rigorous model validation, including a detailed methodological comparison and potential recalibration, to enhance the accuracy of the mode choice model for the Ring Road BRT system.

6 Conclusion

This research assessed the feasibility and impact of a BRT system on the Ring Road in Greater Cairo. Currently, transportation relies heavily on microbuses and private cars. The introduction of BRT is expected to attract passengers from these modes. Higher fuel prices encourage public transport use, but fare increases can offset this. Commuters prioritize affordable BRT fares, even with longer wait times, but travel time reduction increases BRT's appeal. Banning microbuses from the Ring Road is seen as the most effective policy for BRT success. Model validation suggests a need for further refinement of the ridership predictions.

Building upon the analysis of passengers' mode choice behavior using Logit calibration of advanced discrete choice models and Stated Preference data, as outlined in this research, this study assessed the feasibility and potential impact of introducing a BRT system on the Ring Road in Greater Cairo. The current transportation landscape is characterized by heavy reliance on microbuses and private cars, and a primary objective was to determine the BRT's potential to attract commuters from these dominant modes towards more sustainable mass transit.

The findings from the mode choice analysis reveal key factors influencing passengers' decisions. While external factors like higher fuel prices naturally encourage a shift towards public transport, this effect can be mitigated by increases in BRT fares. Crucially, the analysis indicates that commuters prioritize the affordability of BRT fares, even potentially tolerating longer wait times for a lower cost. Conversely, a reduction in overall travel time significantly enhances the attractiveness and competitive edge of the BRT system. Policy simulations based on the model suggest that banning microbuses from the Ring Road emerges as the most effective policy measure for maximizing BRT ridership and ensuring its success.

However, the process of model validation highlighted the inherent complexities in predicting ridership accurately and suggests a need for further refinement of the predictive models to

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