MICROMOBILITY - A CLOSER LOOK AT THE CASE OF BUCHAREST

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Abstract.

This paper examines the traffic safety of users and non-users of micro-mobility, the necessity of a public-private partnership for an improved and coherent urban mobility strategy, the level of consumer satisfaction based on perceived safety and convenience, and the impact of the Covid-19 pandemic on the micro-mobility industry within the urban area of Bucharest, Romania.
Micro-mobility is the focus of intense media attention nowadays. It is well-established that this form of mobility appears to be here to stay and also, in a fast-evolving urban transport environment, it is changing how people move on a daily basis. In the meantime, it is bringing alongside its mobility revolution new and important challenges for both riders and non-riders.
In order to achieve the objectives, it was appealed to specialized literature, an interview with a representative of an important shared electric vehicle company, a questionnaire built for micro-mobility users, and testing the hypotheses formulated through statistical analysis procedures.
The results showed a strong conclusion in the same hypothesized direction: even if Covid-19 was a catalyst for the continuous growth of micro-mobility in Romania, the citizens will not leave traditional vehicles for micro vehicles unless further improvements are made by both private service providers and public authorities for a higher level of safety for both riders and non-riders, and ideally, these improvements are made in a coherent strategy of urban mobility in Bucharest.
This paper offers a strong overview of the micro-mobility in Bucharest, Romania, and also a better understanding of the key pillars of further development work.

Keywords: *electric mopeds, electric scooters, micro-mobility, safety, shared vehicles, transportation, urban mobility.*

Introduction

Micromobility is a new and strongly debated term that refers to a rapidly evolving range of light vehicles that are rapidly gaining popularity on city streets worldwide. “Micro-vehicles” appear to be released on a daily basis for private or shared use on congested city streets. The expansion of shared e-bike and e-scooter companies exemplifies the breadth of their popularity, which was perhaps unforeseeable. Micro-mobility also refers to privately owned vehicles that date back over a century: bicycles, kick scooters, and even powered standing scooters (Gibson, 1915) and powered skates (Scientific American , 1906).

Horace Dediu, an American industry analyst, and investor, coined the term micro-mobility. It began in 2016 by introducing connected bicycles, scooters, and moped-sharing services. The term "micro" can refer to both the vehicles used, typically less than 500 kg, and the short-distance trips that can be entertaining, cheap, and convenient, according to (Dediu, 2019).

Micro-mobility appears to be a long-term trend. The development of lightweight, powered vehicles enabled the portable electric power revolution, which began with the invention of the lithium-ion battery in 1991. (National Academy of Engineering, 2014) These micro-vehicles have a low environmental impact, producing little noise and emitting no exhaust. Compared to other vehicle types, their lightweight suggests a lower carbon footprint over the vehicle's life cycle (OECD/ITF, 2020). Bicycles and other human-powered micro-vehicles also benefit public health by keeping people active. Smaller vehicles also use less space, which is the city's most valuable resource. Micro-mobility appeals to both individuals and policymakers for all of these reasons.

Who is the target audience for micro-mobility? In car-oriented cities, the majority of cyclists are young to middle-aged males. Conversely, cycling is more inclusive in bicycle-friendly cities, with a higher percentage of women, children, and seniors participating (Garrard et al., 2012). Using standing e-scooters in shared fleets may follow a similar pattern, but the cost of such services may also be a factor. In a pilot study, the (City of Santa Monica, 2019a) gathered data on shared electric scooters and bikes operated by private companies. The early adopters were mostly men (67%) and between the ages of 25 and 34 (64%) with a higher-than-average income distribution.

However, data collected in Washington, D.C. indicates that shared micro-mobility provides new options for traditionally underserved communities, and that adoption of shared micro-mobility was higher among black and African-American residents. (Clewlow, 2018)

The media focuses a lot of attention on the safety of micro-vehicles and shared micro-mobility services. Countries and cities have begun adapting road safety regulations to include micro-mobility, resulting in a patchwork of regulations. In 2019, “personal mobility devices” were incorporated into traffic regulations in France and Germany, requiring micro-vehicle users to ride in cycling facilities where they exist (JORF, 2019). Since 2013, kick-scooters and e-scooters in Portugal have been subject to the same traffic laws as bikes and e-bikes.

Conversely, micro-vehicles in South Korea are subject to the same regulations as cars and are not permitted to use bike lanes (Road Traffic Act, 2019). Motorized micro-vehicles are simply prohibited from using public roads in the United Kingdom and Ireland until definitions of vehicles permitted for use on the road are updated to include them.

Literature review

The success of micro-mobility has been made possible by technological advances and innovations in business models, has encouraged the development of new shared mobility services, which use small, often electric vehicles through services operated by private companies, within a sharing system and offer new opportunities to travel in the

city, as preferences for urban mobility change. Although it offers many opportunities, micro-mobility also involves challenges related to regulation and infrastructure. (Heineke, 2022) (Nikolaus Lang, 2022) The existence of a public-private partnership to facilitate conditions for carrying out traffic activity with vehicles like mopeds, scooters, bicycles or other similar examples is a need that is becoming increasingly pressing, in a context in which micro-mobility has become an option for some of the most important cities in Romania, particularly in this paper in Bucharest.

Shared micro-mobility services are intuitive and easy to use, offering sustainable travel options for short journeys and can be a solution for connecting with public transport for longer distances. Different conceptual and technical solutions exist, starting from systems with predetermined parking stations to those completely independent of fixed parking points. (Dediu, 2019) Although it offers a number of benefits, the spread of micro-mobility also generates a number of (negative) externalities and gives rise to controversy due to the importance given to the feeling of traffic safety of users of micro-mobility. (OECD/ITF, 2020)

Micro-mobility can offer a number of benefits to both users and (administrations) of cities, such as intuitive and easy-to-use sustainable mobility options for short journeys (often faster than walking or other means of transport). Such vehicles require a modern, technology-based, and attractive solution for target groups who would not otherwise be willing to give up driving. The level of consumer satisfaction depends very much on the safety conditions mentioned above, but also on an important factor: how easily they can access these services through the conditions offered by the infrastructure. (OECD/ITF, 2020) (OECD/ITF, 2020)

During the Covid-19 pandemic many governments recommended and then imposed social distancing. Therefore, the limits on the movement of goods and people have forced the whole mobility industry to reimagine itself. In March and April 2020, it seemed like the majority of the well-established shared micro-mobility providers of Europe were going to have a very unexpectedly unpleasant year — but nearly all of them have regained traction, buoyed by highly increasing consumer interest in open-air convenient mobility alternatives. (Kersten Heineke, 2020; Aoyong Li, 2021). According to McKinsey's research, the profitability of shared e-scooters could increase by up to 5% after the Covid-19 pandemic (Figure 1).

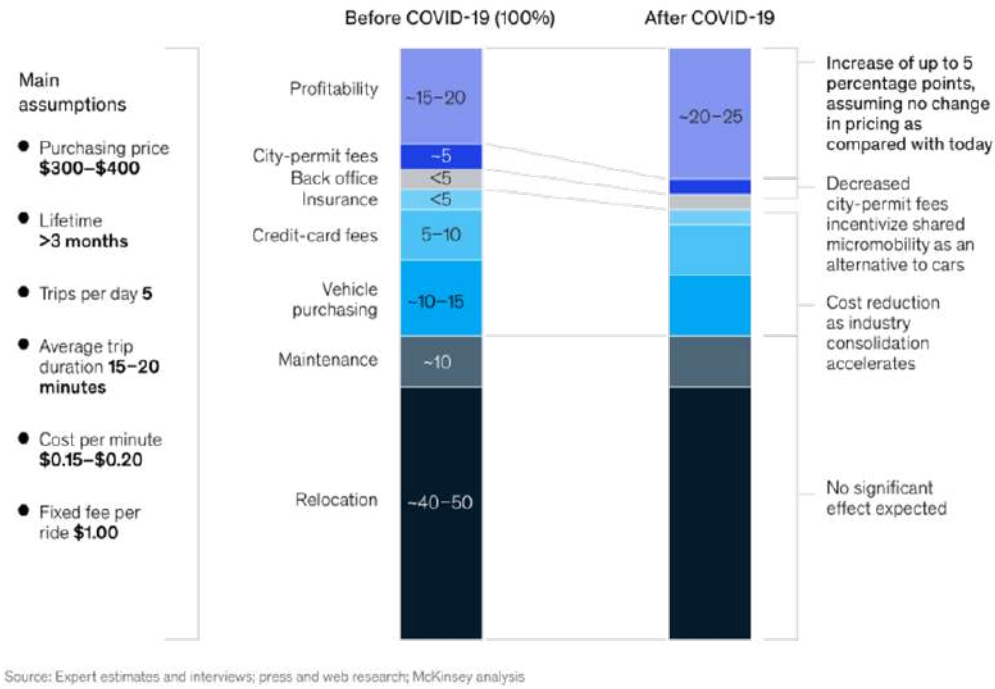

Figure 1 - Estimated breakdown of costs per ride for a shared free-floating e-scooter

Methodology

For a direct approach to the dynamics of the vehicle access phenomenon that refers to the concept of micro-mobility in Bucharest, we call for procedures for quantitative analysis of data collected by applying a questionnaire built in the digital environment disseminated through online communication channels - social media, namely, the WhatsApp platform. The collected data was analyzed through the IBM SPSS Statistics Version 26 program and the SPSS Amos extension, the same statistical analysis program.

To validate the attributes of the questionnaire, we will further discuss methodological issues and assess the level of adequacy through statistical analysis performed in the programs mentioned before by reporting on the chosen topic and data collected from respondents.

The objectives of this paper follow multiple dimensions of the dynamics of the micro-mobility concept, customized at the level of Bucharest. The aspects we follow concern two attributes through which the variable micro-mobility is operationalized: aspects related to the level of development of micro-mobility in the capital by reference to infrastructure and consumer perception, by appealing to consumption behaviors and the level of satisfaction obtained in following access to these types of vehicles. The constructed questionnaire aims to evaluate the benefits of an integrated mobility ecosystem by using real-world data to support confirming or refuting research hypotheses.

The objectives will be achieved by appealing to the specialized literature, a case study on micro-mobility in Bucharest, the questionnaire built for micro-mobility consumers, and testing the hypotheses formulated through statistical analysis procedures. As a result of the aforementioned, we have identified four main hypotheses:

The first hypothesis is: A public-private partnership would lead to a coherent and efficient urban transport strategy; therefore, it would improve the living conditions of the community.

The second hypothesis is: Adoption rate of micro-mobility would be higher if rides were safer for riders and non-riders.

The third hypothesis is: Adoption rate of micro-mobility would be higher if rides were more accessible.

The fourth hypothesis: The Covid-19 pandemic did not jeopardize micro-mobility, but on the contrary.

The specialized literature, reviewed in the previous section, offers a theoretical framework through which we will detail the concept of micro-mobility and an exhaustive analysis of the global context, then transition to local issues to support the validation of objectives and hypotheses formulated by the case study in Bucharest. At a 90% confidence level and a 7% margin of error, the sample size should be at least 139 valid answers (Milton, 1986). The questionnaire completed by the respondents recorded 159 valid answers and was built on several sides of the micro-mobility concept as a measuring instrument. A 6-level Likert-type scale was considered to construct the questionnaire items. To bypass avoidant responses, respondents are forced to provide a perspective as close as possible to the perceived reality of access and how to report this type of mobility in Bucharest. This element can be an inconvenient source to complete, but providing an answer that tends towards a concrete direction on variables such as the level of satisfaction with access to micro-mobility, for example, can provide a realistic picture of the concept.

The statistical analysis of the questionnaire was performed by SPSS and SPSS Amos and graphical representations were generated through the same programs or the author's own processing of the relationships between variables. Factor analysis was supported by the following models: exploratory factor analysis, confirmatory factor analysis, and discriminatory factor analysis.

In order to determine the internal consistency of the factors identified in the questionnaire, the value of the Cronbach Alpha parameter was taken into account, referring to the latest references in assessing its importance and reporting according to the most recent considerations made by (Vaske, Beaman, & Sponarski, 2017) .At the same time, the values of the KMO measurement were taken into account for measuring the adequacy of the applied model, as a condition of the possibility of applying the factor analysis.

Results and discussions

Internal consistency

The questions in a questionnaire are designed to measure a certain attribute (attitude, factor, behavior, knowledge). Internal consistency is defined as the property of items that correlate with the "overall score" of the test or scale to which it belongs. Since all items must reflect a certain attribute, they must manifest a common variance, correlate with each other, and at the same time correlate each individual with the score that reflects that attribute. The correlation between an item and the total score, from which that item is omitted, indicates the relevance of that item to the overall test result. When each item is relevant, we can say the test is "internal consistency". Another facet of the consistency of an instrument is its safety in repeated applications. It can be described as the stability of the score when that instrument, or an equivalent alternative form, is applied to the same subjects.

Without being the only statistical procedure usable in such situations, the Cronbach alpha coefficient is by far the best known of all, being used to indicate the accuracy of measuring a test, the internal consistency, and the fidelity of an instrument. Normally, the value of the Cronbach alpha index tends to increase as the number of items increases. The basic criterion for this range of values of the Cronbach alfa index is to have a value as close as possible to 1. The values can be recorded between 0 and 1. The level of 0.70 is accepted as a threshold by most researchers, the value of Cronbach's alpha cannot be less than 0.60. (Sava & Popa, 2011)

To test the internal consistency of the constructed questionnaire, we refer to the Cronbach Alpha parameter, obtained through the Reliability Analysis procedure from the SPSS program.

According to the literature, a Cronbach Alpha $\alpha = 0.937$ is close to the ideal case, namely the approximation of the value 1. For the present questionnaire, the value thus recorded is one that ensures internal consistency and indicates the accuracy of measurement of the questionnaire in terms of consistency, but also fidelity as a tool.

Characteristics - descriptive statistics and discriminatory analysis of factors

Next, we will follow the characteristics of the questionnaire, by referring to the qualitative parameters of descriptive statistics, taking into account the way in which the questionnaire covers certain specific benchmarks in the way consumers perceive micro-mobility in Bucharest.

Items that refer to the demographic data of the sample of respondents - Q1 and Q2. Thus, we can talk about the age variables, by reporting more age groups, and gender respectively (Table 1).The 159 respondents responded to the age-related item with a proportion of 46.5% as female and 53.5% as male.

Table 1. Frequency analysis of the variable gender (Source: Authors own research)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	74	46,5	46,5	46,5
	Male	85	53,5	53,5	100,0
	Total	159	100,0	100,0	

Regarding the age group of Bucharest residents who completed the questionnaire, we are talking about a special trend as follows: 66,67% of the respondents are between 16 and 18 years old, 17,61% are 19 to 24 years old, 7,55% are 25 to 30 years old, and the rest are between 31 to 60 years old.

Car users represent 67.92% of the sample and up to 100% choose another mobility option. The question refers to possessing such a vehicle, so this does not prevent access to micro-mobility in Bucharest through bike-sharing options. For example. 18,87% of the responders do not own any transportation vehicle. The fourth question verifies the existence of consumption behavior. All 159 respondents had the option to set the level of interest given to this type of transport, by shared micro-mobility services, verifying this option as a real solution to which they apply in traffic, whether or not they are owners of micro-mobility vehicles (feature verified in item Q3). According to Figure 2, the histogram of the distribution of values is balanced, with an asymmetric tendency to the right and a platykurtic shape.

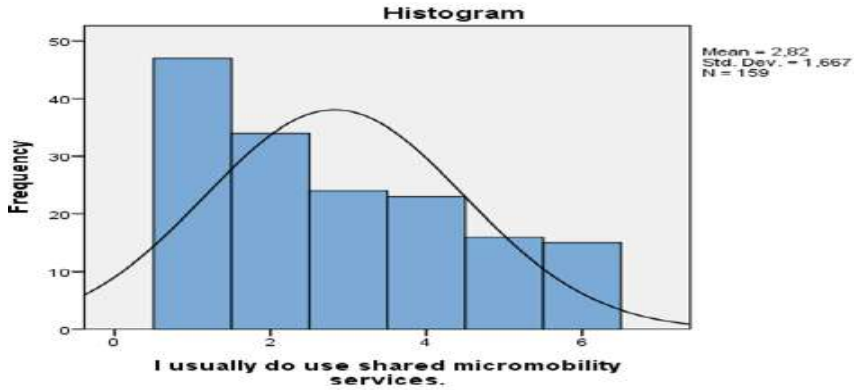

Figure 2- Histogram of Q4 item

The parameters of symmetry and vaulting are defined by values that provide the characteristics of right asymmetry and the platykurtic distribution by reference to the interpretation values. For a symmetry parameter - skewness greater than 0 - the distribution of values will show an asymmetry to the right, while a vaulting parameter - kurtosis less than the value 1 - has a platykurtic distribution. At the same time, the average of the answers tends towards the level 3 response option, which defines the consumption level of micro-mobility in Bucharest at a satisfactory level and keeping the same level of openness constant up to level 6.

Items from Q5 to Q7 show consumers' preference for three types of micro-mobility vehicles, the most common in Bucharest; bicycle, scooter, and moped. The results show that the bicycle is the preferred vehicle; 54,72% of the respondents use it. 1,89% of the respondents stated that they are always choosing a scooter or a moped, while more than 69% stated that they never choose one of those types of vehicles.

Items Q8 to Q12 refer to the level of consumer satisfaction with micro-mobility consumption in relation to micro-vehicle access conditions. According to the descriptive analysis of the items, the value distributions indicate asymmetries to the right and left, but platykurtic forms, except for the distribution of item Q10, which approaches to the case in which the value of the kurtosis indicator approaches 1 and indicates a leptokurtic form of the distribution in terms of vaulting. Simultaneously, we observe in Pearson correlations statistically significant correlations between items, having moderate or strong association relations between items for a confidence threshold of 99%, and respectively 95%.

Items Q13 to Q17 refer to how local infrastructure responds to consumer needs by making decisions to facilitate access to micro-mobility through an efficient public-private partnership between public administration and private micro-mobility service providers. According to the items' descriptive analysis, the distributions of the values indicate asymmetries to the right, but platykurtic shapes. At the same time, we observe in Pearson correlations statistically significant correlations between items, having moderate or strong association relations between items, for a 99% confidence threshold.

Items Q18 to Q23 refer to how consumers have a significant level of willingness to use micro-mobility. According to the descriptive analysis of the items, the distributions of values indicate asymmetries to the right and to the left, but platykurtic forms, with kurtosis indices lower than the value 1. Concurrently, we observe statistically significant correlations between items in Pearson, having moderate or strong association relations between items, for a 99% confidence threshold.

Items Q24 to Q31 refer to the level of safety perceived by users when accessing micro-mobility services. According to the descriptive analysis of the items, the value distributions indicate asymmetries to the right and left, but platykurtic forms, with kurtosis indices less than 1, except for items Q30 and Q31 which approaches a leptokurtic distribution at kurtosis index values of 0.999 and 0.696. We observe in Pearson correlations statistically significant correlations between items, having moderate or strong association relations between items for a confidence threshold of 99%, and respectively 95%.

Items Q32 to Q34 measure the level of safety consumers perceive according to the means of micro-mobility transport. The bicycle is the most preferred vehicle, while mopeds are perceived as the most dangerous.

Items Q35 to Q38 measure an increasing trend in the use of shared micro-mobility vehicles in the context of the COVID-19 pandemic. According to the descriptive analysis of the items (Table 2), the distributions of the values indicate the asymmetries to the right, with kurtosis indices lower than the value 1, so platykurtic distributions. Also, we observe in Pearson correlations statistically significant correlations between items, with strong association relations between items, for a confidence threshold of 99%.

Table 2. Descriptive analysis of items that measure a tendency to increase the frequency of use of micro-mobility in the context of the COVID-19 pandemic (Source: Authors own research)

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Q35	159	1	6	2,47	1,657	,917	,192	-,325	,383
Q36	159	1	6	2,47	1,630	,996	,192	-,110	,383
Q37	159	1	6	2,50	1,606	,831	,192	-,451	,383
Q38	159	1	6	3,00	1,757	,468	,192	-1,084	,383
Valid N (listwise)	159								

Exploratory factor analysis

Exploratory factor analysis (EFA) is one of the most widely used statistical techniques. Its main purpose is to identify the number and nature of the factors underlying a set of overt variables. Factor analysis solves two types of problems: reducing the number of variables to increase the speed of data processing and identifying hidden patterns in the relationships between data. Factor analysis refers to a wide range of statistical techniques used to represent a set of variables in accordance with a small number of hypothetical variables, called factors.

The structure of the SPSS database contains 159 records and 36 items, of which the opening ones will not be considered, aiming at demographic data about the respondents.

After applying the Principal Component Analysis method, results were obtained that described descriptive statistics, correlation matrix, KMO and Bartlett test, commonality, total variance explained, Scree Plot image, component matrix, and component matrix after rotation.

The KMO (Kaiser-Meyer-Olkin) index is used to compare the dimensions of the observed correlation coefficients with the dimensions of the partial correlation coefficients.
The value of Bartlett's test (3312,694 Sig = 0.000 <0.05, KMO = 0.871), is small enough to reject the hypothesis that the variables are uncorrelated. As a result, there is a strong relationship between the data. These values indicate the presence of one or more common factors which motivates the application of a procedure to reduce the number of factors, for a statistically significant value, which presupposes the adequacy of the proposed model.

Commonness represents that part of the variance of a variable explained by the structure of a factor (Pohlmann), or in other words, the common character of a variable represents that part of the variance of the variable that is common to the variance of other variables. Minimum values of the common character for certain variables indicate that those variables are not well represented by the applied factorial model. In this case, most variables are well represented by the factorial model used.

The first information specific to the factor analysis is presented by the Total Explained Variance. Using the method of Analysis of Main Components (ACP), a number of 6 main components, so-called factors, were generated, all 6 meetings the selection criteria (eigenvalues> = 1).

In Graph 10, the eigenvalues for all main components, obtained by applying the ACP method, are represented graphically in a sequence of main factors. The number of factors is chosen where the graph levels show a linear decreasing pattern. The result suggests the existence of a five-factor solution.

The matrix of components, provides the list of items and their contribution to the loading of each of the selected factors, in terms of correlation. The data refer to the initial factorial solution, before applying the rotation procedure.

In the matrix of rotating components containing the data obtained after the application of the factor rotation procedure by Varimax with Kaiser Normalization, we notice the alignment of 5 factors is observed: the level of safety perceived by consumers; the level of interest given to micro-mobility, the level of satisfaction in using micro vehicles, the level of access to micro-mobility in relation to infrastructure, the level of perceived development of the public-private partnership, the growing trend of consumer interest during COVID-19

Using this type of factor analysis, we can obtain useful information on the factors that have a great influence on people's quality of life, giving statisticians the opportunity to track its upward or downward evolution by reporting micro-mobility.

Confirmatory factor analysis

Byrne argues that confirmatory factor analysis (CFA) procedures for validating an instrument are indicated when the investigated instruments have reached a certain degree of maturity, and when there is sufficient data on their factorial structure.

Confirmatory Factor Analysis

Factor Loadings

Factor	Indicator	Estimate	SE	Z	p
Factor 1	The level of interest given to micromobility	0.938	0.126	7.44	< .001
	The level of safety perceived by consumers	4.477	0.619	7.23	< .001
	Level of satisfaction in using micromobiles	6.286	0.490	12.82	< .001
	The level of access to micromobility in relation to infrastruct	4.244	0.446	9.51	< .001
	The level of perceived development of the public-private partne	5.201	0.425	12.25	< .001
	The growing trend of consumer interest during COVID-19	4.220	0.440	9.60	< .001

Factor Estimates

Factor Covariances

		Estimate	SE	Z	p
Factor 1	Factor 1	1.00*			

* fixed parameter

Figure 3 – Confirmatory Factor Analysis
(Source: Authors own research)

Using the JAMOVI program, to test the construct validity, a confirmatory analysis of the 6-factor model was used (Figure 3).
This could be done because the condition of normal data distribution for each of the 6 factors of the instrument was met. Following the confirmatory factor analysis, a value of the fit of the model was obtained (Figure 4) $\chi 2$ (9) = 32.0, p <0.001 which indicates significant differences between the raw data matrix and the matrix obtained based on the links specified in the model. This significant value, however, may be due to the relatively large number of the sample, so it cannot be considered a criterion for rejecting the model, with a total of 159 records recorded.

Model Fit

Test for Exact Fit

χ^2	df	p
32.0	9	< .001

Fit Measures

			RMSEA 90% CI	
CFI	TLI	RMSEA	Lower	Upper
0.942	0.904	0.125	0.0798	0.173

Figure 4 – Model Fit
(Source: Authors own research)

The RMSEA indicator had a value 0.125, relatively acceptable, the TLI indicator had a value 0.904, adequate, and the IFC indicator had a value 0.942, considered desirable. (Sava & Popa, 2011) Thus, we can conclude that the six-factor model is validated.

Conclusions

Authorities should repurpose space to create physically protected micro-vehicle lanes to create a safe and connected network for micro-mobility. This network should be more appealing than sidewalks, with design guidelines for a wide, safe cycling infrastructure being developed. Light separation on busy streets and traffic filtering on residential streets are proven techniques for rapid, low-cost development. Authorities at all levels should increase their efforts to address dangerous driving habits such as speeding, distracted driving, and intoxicated driving.

There is a lack of knowledge about the safety performance of various micro-vehicle types and models, the role of various crash factors, and the most effective countermeasures. Micromobility safety research necessitates accurate crash data from police and health services, as well as trip data from governments via operators, travel surveys, and on-street observation. The collection of this information should be a top priority for road safety organizations.

Operators of shared micro-mobility should examine their pricing structures to ensure they do not encourage risk-taking. Renting by the minute can encourage people to speed or break traffic laws. As a result, businesses should reduce minute-based charging and compensate with other methods. A fixed-amount trip charge, a distance-based charge, or a membership fee are all possibilities. In addition, in partnership with central authorities, they can be integrated into multimodal transport platforms, where users can access different types of vehicles, both operated by public authorities or by private companies, and have the possibility to switch effortlessly from one transport service to another while commuting.

Although it offers many opportunities, micro-mobility also involves challenges related to regulation and infrastructure and gives rise to controversy due to the importance given to users' feeling of traffic safety. The existence of a public-private partnership to facilitate conditions for carrying out traffic activity with micro-vehicles is a need that is becoming increasingly pressing, in a context in which micro-mobility has become an option for some of the most important cities around the globe, particularly in this paper in Bucharest.

Micro-mobility can offer a number of benefits to both users and communities, such as intuitive and easy-to-use sustainable mobility options for fast short journeys. The micro-vehicles require a modern, technology-based, and attractive solution for target groups who would not otherwise be willing to give up driving. The level of consumer satisfaction depends very much on the safety conditions mentioned above, but also on an important factor: how easily they can access these services through the conditions offered by the infrastructure.

Even though the Covid-19 pandemic imposed social distancing, forcing the whole mobility industry to reimagine itself, micro-mobility has regained traction, buoyed by highly increasing consumer interest in open-air convenient mobility alternatives.

The present work has certain limitations and would benefit from further improvements. Firstly, the sample might be biased. In this case, the people who responded to the survey questions may not truly be a random sample due to the limited ability to gain access to the appropriate type or geographic scope of participants. Secondly, the research instrument comprised self-reported answers, hence subjective measures for all constructs, which should be thoroughly considered in other methodological designs.

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