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WHAT FACTORS AFFECT BICYCLE COMMUTING? AN EMPIRICAL ANALYSIS IN TBILISI AND WARSAW

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Abstract

Purpose: The purpose of the article is to identify the factors that influence commuting by bicycle with a specific focus on Tbilisi and Warsaw. Based on the testing of hypotheses, the authors intended to determine how different factors affect commuting by cycling in these two cities.
Design/methodology/approach: The study uses a structured and self-administered online questionnaire of bicycle users in both cities. The survey collected data on cycling behaviour, motivations, and perceptions of cycling infrastructure. The population of the cycling community was 12,000 in Tbilisi and 14,000 in Warsaw. The Binary logit regression model was used to determine the influence of variables. The questionnaire is in line with The National Institute for Transportation and Communities of USA.

Findings: The study's findings suggest that while commuting by cycling has significant environmental benefits, there are significant barriers to its adoption, including a lack of infrastructure, safety concerns, and cultural attitudes towards bicycle commuting in Tbilisi and Warsaw. The study also reveals different attitudes among bicycle users.
Research limitations: The study's limitations include the relatively small sample size of the survey and the limited scope of the quantitative survey. Nevertheless, the study provides valuable insights into the opportunities and challenges of promoting cycling as a sustainable mode of transport in these two cities.
Practical implications: The practical implications of the study are twofold. First, it highlights the need for a coordinated effort by local authorities, civil society, and private actors to promote cycling as a sustainable mode of transport. Second, it provides specific recommendations for policymakers on how to overcome the barriers to cycling and promote this sustainable means of transport.
Originality/value: The study's originality lies in its focus on two cities with different cultural and political contexts, providing a comparison of how cycling promotion strategies may vary across contexts.

Keywords: Hypothesis testing, Model Construction and Estimation, Social Choice, Air Pollution, Transportation, Safety

JEL classification: C12, C51, D71, Q53, R41

Introduction

The increasing agreement regarding the benefits of cycling has captured policymakers' attention, spurring their desire to elevate the proportion of individuals who choose bicycles as their mode of commuting (Banerjee *et al*., 2021). Urbanization and automobile ownership have been following an increasing trend all over the world due to various reasons. This trend is more visible in developing countries. As a result, the major cities in the developing countries have been experiencing a continuous deterioration of the transportation system and air quality, oftentimes due to proactive planning and lack of resources (Mansoor *et al*., 2021). According to research those who cycled or walked more had lower daily mobility-related CO_2 emissions, while those who drove more or used public transport more had higher daily total CO_2 emissions (Brand *et al*., 2021). The rising global attention towards cycling as a significant mode of transportation for commuters is attributed to its environmental and health advantages, as well as its potential for seamless integration with public transportation systems (Nkurunziza *et al*., 2012). Gaining insight into the fundamental factors that impact bicycle commuting is crucial in formulating impactful policies aimed at fostering a city that is conducive to cycling. The challenges of achieving sustainable urban transport are widely acknowledged and prevalent

in developed nations. To devise effective cycling policies, it is imperative to comprehend the pivotal factors that shape bicycle commuting (Muñoz *et al*., 2016).

Urban centres across the globe are grappling with the mounting issue of traffic congestion, which not only triggers a multitude of social conflicts but also disrupts the delicate balance of the natural environment. As the primary catalyst behind a host of transportation challenges, congestion necessitates the immediate adoption of a transport development model that ensures optimal mobility in line with societal demands while minimizing adverse environmental impacts (Roman, Roman, 2014). Urban cycling offers numerous advantages for individuals, ranging from improved health and reduced traffic congestion to environmental sustainability. Nonetheless, the planning and implementation of cycling infrastructures in large cities encounter significant challenges. To address these obstacles, a comprehensive understanding of the factors that foster cycling in cities as well as the barriers impeding its growth is essential (Iwińska *et al*., 2018).

Despite the ongoing discussions regarding the enhancement of cycling infrastructure, a gap in understanding persists at the decision-making level, which fails to consider the interconnectedness between cycling and various social, cultural, and environmental elements that significantly impact the feasibility of bicycling as a viable and sustainable mode of transportation (Mohiuddin *et al*., 2022). In developed countries, commuting and recreational bicycle usage are prevalent. Additionally, there exists a notable discontentment regarding the development and standard of cycling infrastructure (Milković, Štambuk, 2015). Formulating effective strategies to promote cycling necessitates a comprehensive understanding of the factors influencing bicycle commuting. Traditional approaches to analysing cycling patterns often rely on utility theory, which assumes that individuals select the most optimal transportation mode by evaluating factors such as costs, time, and effort (Heinen *et al*., 2011). The cultural views can damage the opportunity of high penetration of non-motorized transport in some developing countries even if other factors are sufficiently appropriate (Mansoor *et al*., 2021).

Drawing from the existing literature, it can be asserted that quantitative studies on cycling in third-tier countries are scarce. We believe that this study will, to some degree, enhance the understanding of factors influencing bicycle usage, particularly within developing countries. In order to fill the gap in the literature, we conducted quantitative research to reveal the factors that affect bicycle commuting.

The article is structured into four distinct sections. The initial section implies the literature review, exploring the motivations and outcomes associated with bicycle commuting. It also highlights pertinent queries and concerns that warrant a slightly different research approach

compared to previous studies. The subsequent section provides an overview of survey and research data both in Tbilisi and Warsaw. Moving forward, the third section delves into the survey methodology employed and presents the collected data. Finally, the fourth and concluding section outlines the computations and resultant findings. The article concludes by thoroughly examining the study's discoveries and presenting the corresponding conclusions.

1. Literature review

This section of the article briefly summarizes the determinants of cycling behaviour and most recent research on bicycle commuting.

1.1. Determinants of Cycling

There are several reasons why individuals may choose to use a bicycle for commuting instead of a car.

Environmental considerations: Bicycles do not produce emissions or contribute to air pollution, making them a more environmentally friendly option compared to cars. Choosing a bicycle helps reduce the carbon footprint and decrease reliance on fossil fuels (Torrisi *et al*., 2021). The findings suggest that a high level of environmental awareness exerts a positive effect on the use of more environmentally friendly transport modes (Bai *at al*., 2020).

Cost savings: Bicycles are generally much cheaper to buy and maintain than cars. There are no fuel costs or parking fees associated with bicycles, and maintenance expenses are typically lower as well. This makes bicycles an attractive option for individuals looking to save money on transportation (Litman, 2022).

Health and fitness benefits: Cycling is a form of physical exercise that provides numerous health benefits. By choosing to ride a bicycle, individuals can incorporate physical activity into their daily routine, improve cardiovascular fitness, build muscle strength, and maintain a healthy weight (Assunçao-Denis, Tomalty, 2019).

Avoiding traffic congestion: In many urban areas, traffic congestion can be a significant issue, leading to delays and frustration for car users. Bicycles offer greater manoeuvrability, allowing riders to navigate through congested areas more efficiently and reach their destinations faster (Pucher, Buehler, 2012).

Convenience and parking: Bicycles require much less space for parking compared to cars. Finding parking for a bicycle is usually easier and quicker, especially in crowded city

centres where finding car parking can be a challenge. Bicycles also offer the advantage of being able to access areas where cars may be restricted or prohibited (Heinen, Buehler, 2019).

Shorter commute times: In dense urban environments, bicycles can often provide faster commute times compared to cars. They can manoeuvre through traffic, take advantage of bike lanes or paths, and sometimes follow more direct routes that may not be accessible by car (Lusk *et al*., 2013).

Enjoyment and recreational purposes: Many people simply enjoy cycling and find it a pleasurable way to commute. Riding a bicycle allows individuals to connect with their surroundings, enjoy the fresh air, and experience a sense of freedom and independence (Heinen *et al*., 2012).

1.2. Empirical studies of researchers

Despite receiving public support, new policy directions and reforms in Tbilisi have failed to address the persistent challenges faced by residents in relation to the mass transit system and congestion. The city remains burdened by an unreliable public transport network and constant traffic congestion (Bankwatch Network, 2022). Being a nation that emerged from the post-Soviet Union era, Georgia relied heavily on privately owned minibuses as the predominant mode of transportation. However, in 2019, significant strides were taken towards sustainable urban mobility with the introduction of a comprehensive plan in Tbilisi. This plan prioritized public transport and pedestrian-friendly infrastructure. As part of this initiative, a prominent avenue was transformed into a complete new street model, and hourly parking was implemented in the city centre. Despite these efforts, the issue of traffic congestion continues to persist (Kacharava *et al*., 2021).

In Poland bicycle rental is very popular in Warsaw, both among locals and tourists. The system was a great success and is a big opportunity for other cities that have a bigger mileage of cycling lanes (Roman, Roman, 2014). The bicycle rental service is also available in Tbilisi, although it is relatively new and not as extensive as in Warsaw. The rapid population growth in Tbilisi has led to the urgency of a complete overhaul of the transportation system in the city (Kacharava *et al*., 2021). Researchers identified three fundamental attitudinal factors that influence individuals' inclination towards cycling for commuting purposes. These factors encompassed awareness of the benefits of cycling, direct advantages associated with trip-based cycling, and concerns pertaining to safety while cycling (Heinen *et al*., 2011).

According to the findings of the study, it was observed that a significant segment of the population in Warsaw engaged in cycling activities on an occasional basis. However, the

primary utilization of cycling among residents was predominantly for recreational purposes, which aligns with the prevalent trend observed in regions characterized by low cycling rates (Iwińska *et al*., 2018). The distinctive urban setting of Warsaw, where cycling is predominantly viewed as a recreational pursuit, presented an exceptional platform to delve deeper into the possibilities of promoting cycling as a viable means of everyday transportation.

In order to show us how the same factors operate in two different cities, Tbilisi and Warsaw, it was necessary to introduce some hypotheses. By analysing factors, we tried to reveal the differences that exist in the example of large cities in developing and developed countries.

1.3. Research hypotheses

We introduced 11 hypotheses in order to show how the factors affect bicycle commuting in Tbilisi and Warsaw. After reviewing the literature, we formulated the hypotheses surrounding the study as follows:

$H1_0$ Gender has no effect on the bicycle commuting.

$H2_0$ Age has no effect on bicycle commuting.

$H3_0$ The distance travelled per month has no effect on bicycle commuting.

$H4_0$ The level of safety on city roads has no effect on bicycle commuting.

$H5_0$ The convenience of cycling has no effect on bicycle commuting.

$H6_0$ The caution shown by drivers towards cyclists has no effect on bicycle commuting.

$H7_0$ Availability of bike lanes has no effect on bicycle commuting.

$H8_0$ Availability of bike rental services has no effect on bicycle commuting.

$H9_0$ Availability of bike parking at popular destinations has no effect on bicycle commuting.

$H10_0$ The interconnectivity of cycling infrastructure has no effect on bicycle commuting.

$H11_0$ Cycling promotes initiatives that have no effect on bicycle commuting.

To test each hypothesis, we decided to construct a logit regression model based on both Tbilisi and Warsaw data and then we compared the results.

2. Survey and research data

Our target audience was people who use a bicycle. Data were collected using an online questionnaire that is in line with The National Institute for Transportation and Communities of the USA. The questionnaire was modified, compiled in Google forms, and provided in two

languages: Georgian and Polish. The online questionnaires were distributed in Facebook groups in Tbilisi and Warsaw. The community of bicycle enthusiasts in Tbilisi, with whom we shared the questionnaire, had 12,000 members, and in the case of Warsaw – 14,000. The questionnaire was open for 2 weeks from May 29, 2023. As a result, we received 492 completely filled in questionnaires in the case of Tbilisi and 431 in the case of Warsaw. Accordingly, the response rate for each city was 4.1% (Tbilisi) and 3.1% (Warsaw), which can be considered as good because online surveys typically have a low response rate (Malhotra *et al*., 2017). We preferred to send a questionnaire to the entire population of all bicycle users in these Facebook groups of Tbilisi and Warsaw, since response rate is a major problem, and this fact ensured us a considerable number of responses.

For the purposes of our study, cyclists were asked what was the main purpose of using a bicycle when moving around the city. The questionnaire also included the average cycling distance and safety and comfort issues, which were rated on a 7-point Likert scale (very poor – outstanding). Data by country are summarized in Table 1.

Table 1. Data characteristics

Data	Tbilisi	Warsaw
Research frame (members)	12,000	14,000
Method (email)	Online	Online
Response rate (%)	4.1	3.1
Period	May-June, 2023	May-June, 2023
Significance (α)	0.05	0.05

Source: own study.

3. Methodology and Results

3.1. Dependent Variable

We intended to explore biking decisions for commuting and non-commuting use and to what extent the perception variables influence them. Our dependent variable was binary– whether respondents are cycling for a commuting purpose (=1) or not (=0). We chose to analyse our dependent variable as a dummy variable.

3.2. Demographics

Most of the participants are male in both cities (Tbilisi – 83.4%, Warsaw – 83.7%) and were aged between 26 and 35 years old (Tbilisi – 38.4%, Warsaw – 37.3%). The majority of the participants cycling distance are 21–50 km per month in Tbilisi (20.4%) and 1–20 km per month in Warsaw (28.8%). The purpose of cycling as a means of commuting are little bit different in these cities. In particular, according to our data, bicycles are used for commuting purposes more in Tbilisi (42.7%) than in Warsaw (30.1%). This result is in line with the results of the researchers, who note that cycling is mostly a recreational activity in Warsaw (Iwińska *et al*., 2018).

Table 2. Participants demographic characteristics (%)

Variables	Tbilisi	Warsaw
Gender		
Male	83.4	83.7
Female	16.6	16.3
Age		
<18	5.5	0.7
18–25	23.0	12.4
26–35	38.4	37.3
36–45	22.5	33.3
46–55	6.9	12.4
>55	3.8	3.9
Distance (km)		
1–20	16.6	28.8
21–50	20.4	20.9
51–100	19.7	12.4
101–200	19.4	17.6
201–400	14.9	8.5
>400	9.0	11.8
Purpose		
Commuting	42.7	30.1
Non-commuting	57.3	69.9

Source: own study.

3.3. Independent variables

In accordance with the study, our independent variables are demographic variables such as gender, age, distance travelled per month, which are categorical variables, and perceptual variables such as safety, convenience, driver caution, availability of bicycle lanes, availability of bicycle rentals, availability of bicycle parking, bicycle infrastructure connectivity and cycling promoting initiatives. The responses to selected perception statements are summarized below in Tables 3 and 4. It should be noted that the perceptual variables differ in Tbilisi and Warsaw. In particular, lower evaluations can be found in Tbilisi than in Warsaw.

Table 3. Tbilisi responses to Selected Eight Perception Statements (%)

Statements	Very Poor	Poor	Moderate	Good	Very Good	Excellent	Outstanding
Safety	9.5	21.6	22.8	24.0	10.7	3.2	8.1
Convenience	17.2	23.1	23.0	20.6	8.6	2.7	4.8
Drivers caution	18.2	25.7	21.0	20.6	6.9	2.4	5.1
Bike lane availability	18.1	26.3	21.5	19.1	7.9	2.7	4.4
Bike rental availability	22.7	25.7	20.8	17.9	7.0	1.9	3.9
Bike parking availability	21.1	25.7	20.2	19.1	7.5	2.1	4.3
Bike infrastructure	19.8	24.0	21.3	20.6	8.7	1.5	4.2
Cycling promoting initiatives	20.8	27.1	20.8	18.5	7.1	1.9	3.8

Source: own study.

Table 4. Warsaw responses to Selected Eight Perception Statements (%)

Statements	Very Poor	Poor	Moderate	Good	Very Good	Excellent	Outstanding
Safety	2.0	3.2	7.6	13.4	26.1	11.2	36.5
Convenience	7.3	4.6	8.1	13.9	23.6	9.8	32.8
Drivers caution	9.6	4.0	9.3	12.4	23.1	10.0	31.5
Bike lane availability	8.2	5.9	10.0	13.2	23.3	10.0	29.5
Bike rental availability	7.6	7.2	10.2	15.8	22.5	9.2	27.5
Bike parking availability	9.1	5.4	10.5	12.7	22.6	9.7	30.1
Bike infrastructure	9.1	5.6	9.1	11.4	22.8	9.4	32.5
Cycling promoting initiatives	8.0	7.2	10.9	13.9	23.5	8.7	27.9

Source: own study.

3.4. Modelling approach

Data were aggregated and analysed according to both countries. There is insufficient statistical evidence to reject the null hypothesis at the 5% level of significance. The binary logit regression model is used to determine variables that affect bicycle commuting (1).

$$logit(P(Y=1)) = \beta_0 + \beta_1 Gender_n + \beta_2 Age_n + \beta_3 Distance_n + \beta_4 Safety_n + \beta_5 Convenience_n + \\ + \beta_6 Drivers\ Caution_n + \beta_7 Bike\ Lanes_n + \beta_8 Bike\ rentals_n + \beta_9 Bike\ parking_n + \\ + \beta_{10} Bike\ Infrastructure_n + \beta_{11} Cycling\ initiatives_n + e_n \quad (1)$$

where:

$logit(\cdot)$ – the log-odds function defined as log[p/(1 – p)],

$P(Y = 1)$ – probability of commuting,

e_n – random error/unobservable effect.

Table 5 provides a summary of the model for Tbilisi and Warsaw.

Table 5. Model Summary

Tbilisi			
Step	–2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	501.137[a]	0.162	0.218
Warsaw			
Step	–2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	107.858[a]	0.404	0.573

[a] Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Source: own study.

From the Table above, it can be seen that Nagelkerke's R-square in the case of the Tbilisi model is 0.218, and in the case of Warsaw – 0.573. Which means that in the case of the regression model of Tbilisi, 21.8% of the dependent variable is explained by the independent variables, and in the case of the Warsaw model – 57.3%. Cox and Snell R squared, another measure of goodness of fit in generalized linear models is a pseudo R squared and a modification of the deviance which configures the test interval to lie between 0 and 1 (excluding 1) (Mbachu, Nduka, Nja, 2012). In our case, the Cox & Snell R Square in Tbilisi equals 16.2% and in Warsaw – 40.4%. Therefore, Nagelkerke's R-squared metric reveals a heightened degree of explanatory power of the dependent variable within the regression analysis. We also constructed the ROC (receiver operating characteristic) curve. ROC curves could become a fundamental tool

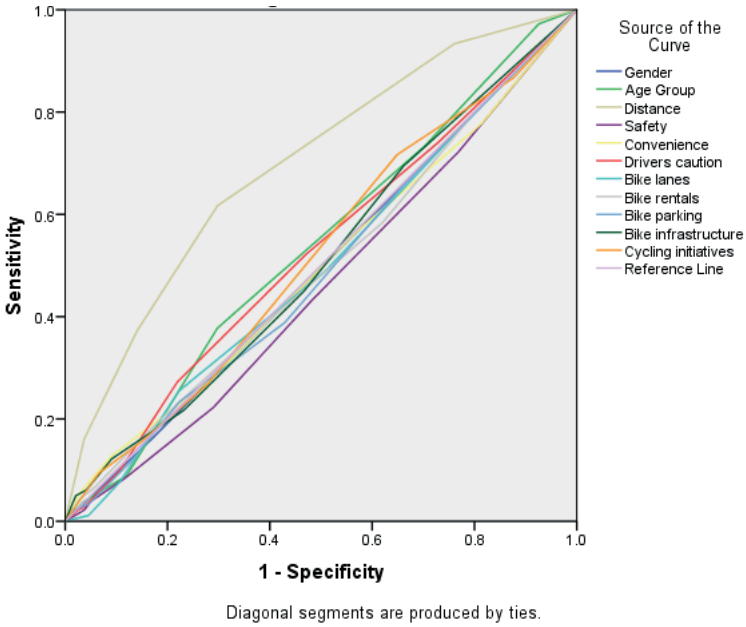

Figure 1. ROC curve Tbilisi

Source: own study.

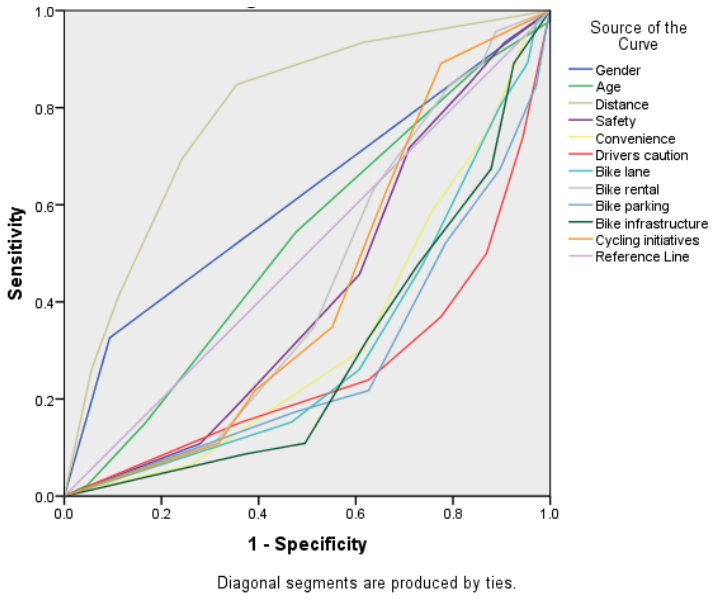

Figure 2. ROC curve Warsaw

Source: own study.

in the assessment, improvement and deployment of regression models (Hernández-Orallo, 2013). It can be seen from the curve (Figure 1) that our independent variable – the distance – was in the acceptable zone (>0.6).

In the case of the Warsaw data, the independent variable – distance was in the excellent zone (>0.8). It should be noted that unlike the Tbilisi data, the Warsaw data are more sensitive.

The output table for our binary logit regression model is presented below.

Table 6. The output of the Binary Logit Regression Model
(Sample size Tbilisi = 492, Sample size Warsaw = 431)

Variable in equation	Tbilisi			Warsaw		
	B	sig.	Exp(B)	B	sig.	Exp(B)
Gender (Base = Male)	–0.196	0.514	0.822	–2.582	0.001	0.076
Age group (r.c. >55)		0.079			0.960	
<18	–0.586	0.477	0.557	20.314	1.000	43.264
18–25	0.228	0.714	1.256	0.143	0.931	1.154
26–35	0.022	0.971	1.022	–0.360	0.815	0.697
36–45	0.709	0.254	2.033	0.259	0.864	1.296
46–55	–0.345	0.631	0.708	0.102	0.949	1.107
Distance (r.c. >400 km)		0.000			0.002	
1–20	–2.880	0.000	0.056	–3.757	0.000	0.023
21–50	–2.107	0.000	0.122	–3.625	0.000	0.027
51–100	–1.955	0.000	0.142	–1.771	0.042	0.170
101–200	–1.155	0.014	0.315	–1.321	0.088	0.267
201–400	–0.864	0.072	0.421	–1.323	0.177	0.266
Safety	–0.214	0.035	0.807	0.520	0.049	1.682
Convenience	0.036	0.733	1.036	–0.276	0.295	0.759
Drivers caution	0.070	0.433	1.072	–0.223	0.305	0.800
Bike lanes	–0.023	0.823	0.977	–0.077	0.788	0.926
Bike rentals	–0.026	0.746	0.975	0.074	0.675	1.077
Bike parking	–0.023	0.787	0.977	–0.343	0.129	0.710
Bike infrastructure	0.108	0.266	1.114	–0.300	0.243	0.741
Cycling initiatives	–0.028	0.712	0.972	0.174	0.324	1.190
Constant	1.601	0.037	4.960	5.394	0.006	220.073

Source: own study.

It can be seen that the statistically significant variables in the case of Tbilisi are distance travelled per month (sig. <0.05) and the level of safety (sig. <0.05). In the case of Warsaw – gender (sig. <0.05), distance (sig. <0.05), and safety (sig. <0.05).

In the Table above, B is the regression coefficient and the constant term, which can be negative. If the B value is equal to 0, Exp (B) is 1, indicating that there is no significant difference between the groups. Exp (B) shows how much the chances are of an event change for every one-step change in the predictor (Tan, Ma, 2021). From our estimated model, looking at distance there are negative B values for both cities, which suggest a negative relationship. It is better to interpret the results in terms of the likelihood of not commuting rather than commuting. This involves 1 divided by the odds ratio.

In Tbilisi, people who travel 1–20 km per month would be 17.8 times less likely to use a bike for commuting compared to those who travel more than 400 km per month.

In the case of Warsaw for every unit increase distance category, 1–20 km would be less likely to use a bike for commuting by a factor of 43.4, 21–50 km category – by a factor of 37.0 and 51–100 km category – by a factor of 5.8. In other words, those people who travel 1–20 km per month are 43 times less likely use a bike to commute than those people who travel more than 400 km per month. Also, in the case of Warsaw, men are 13 times more likely than women to use bicycles for commuting. Our research confirmed the findings that long distance commuting by bicycle are associated with positive attitudes (Heinen *et al*., 2012).

It can be seen from Table 6 that the safety variable in the Tbilisi case has a negative B value. Considering other things being equal, the perception of safety changes the probability of bicycle commuting by 1.2 times. In Warsaw's case the level of safety has a positive B value. From our Table, we can see that if we change the perception of safety by one unit, the likelihood of bicycle commuting will increase 1.6 times. In Georgia, gender does not determine the use of a bicycle as a means of transport. This may be due to the fact that in our opinion the majority of bicycle users in Tbilisi are more enthusiastic about bike commuting and people choose a bike for commuting besides their gender, while in Warsaw recreational cycling is a major motivation. This then indicates the need for additional further research.

Table 7 shows the results of the hypotheses tested by the model. In the case of Tbilisi, 2 out of 11 hypotheses were not confirmed in our model, and in the case of Warsaw – 3.

Table 7. The results of the analysis

Hypothesis	Tbilisi		Warsaw	
	null hypothesis	sig.	null hypothesis	sig.
$H1_0$	Accepted	0.514	Rejected	0.001
$H2_0$	Accepted	0.079	Accepted	0.960
$H3_0$	Rejected	0.000	Rejected	0.002
$H4_0$	Rejected	0.035	Rejected	0.049
$H5_0$	Accepted	0.733	Accepted	0.295
$H6_0$	Accepted	0.433	Accepted	0.305
$H7_0$	Accepted	0.823	Accepted	0.788
$H8_0$	Accepted	0.746	Accepted	0.675
$H9_0$	Accepted	0.787	Accepted	0.129
$H10_0$	Accepted	0.266	Accepted	0.243
$H11_0$	Accepted	0.712	Accepted	0.324

Source: own study.

Conclusions

The purpose of our article was to identify the factors affecting bicycle commuting in two different cities: Tbilisi and Warsaw. We tested eleven hypotheses to determine which factors are statistically significant and the likelihood of using bicycles as a means of commuting. After analysing the data of 492 bicycle users in the case of Tbilisi, the findings indicate that only distance travelled and level of safety are statistically significant. Therefore out of the 11 hypotheses, we rejected 2: $H3_0$ (The distance travelled per month has no effect on bicycle commuting) and $H4_0$ (The level of safety on city roads has no effect on bicycle commuting). In the case of Warsaw, we analysed data from 431 participants, and in this case, gender, distance travelled, and perception of safety emerged as statistically significant variables. Therefore out of the 11, we rejected 3 of the following hypotheses: $H1_0$ (Gender has no effect on bicycle commuting), $H3_0$ and $H4_0$. Based on our findings, it can be inferred that distance travelled and safety are important factors for cycling in both cities. $H1_0$ (Gender) was significant only in the case of Warsaw. All other hypotheses are accepted, which means that age, the convenience of cycling, the caution shown by drivers towards cyclists, availability of bike lanes, availability of bike rental services, availability of bike parking at popular destinations, the interconnectivity of cycling infrastructure and cycling initiatives has no effect on bicycle commuting according to our model. According to our data, in the case of Tbilisi, it was skewed

to the left, indicating that people continue to cycle despite feeling unsafe and uncomfortable. In other words, it means that bike commuters in Tbilisi are individuals who are bike lovers and enthusiasts, and they choose to cycle despite the challenging circumstances. For the purpose of emission reduction, our goal should be to engage all individuals who want to use bicycles as a mode of transportation, even if they do not consider themselves bike enthusiasts. Increasing bicycle commuting is desirable for emission reduction, as it directly replaces CO_2-emitting vehicles. It is favourable that people, once cycling becomes a more convenient transportation option, begin using bicycles for commuting, and not just being limited to bike enthusiasts.

As our $H1_0$ hypothesis testing result shows, gender has an effect on the likelihood of choosing bicycle commuting in the case of Warsaw. Therefore, we believe that additional cycling promotion initiatives are needed to encourage female cycling. In this case, unlike our survey, cycling promotion initiatives may also become important variables. Since safety and distance travelled are also valid variables, a new issue should be included in transport development policy to promote female cyclists who do not have to travel long distances during their daily commutes.

In the case of Tbilisi, according to the $H1_0$ hypothesis testing result gender is not a valid variable, which may be due to the fact that the share of enthusiastic cyclists is higher. The fact from our survey, that in the case of Tbilisi, variables are skewed to the left, also supports this idea. General bike promotion activities are favourable in the case of Tbilisi, which will cause the inclusion of recreational bike users in bicycle commuting at first. Additionally, we recommend introducing bicycle transportation methods to people who do not use it at all. Distance travelled and safety have an effect on choosing bicycle commuting in Tbilisi according to our model. Therefore, if new safety plans are developed in dense urban settlements where residents generally do not have to travel long distances, this will effectively increase the number of bicycle commuters.

In order to promote ecological compatibility, it is imperative to augment the populace engaging in cycling as a means of transportation for commuting purposes. We concur that enhancing these pertinent variables by a unitary increment would significantly impact the probability of individuals adopting bicycles for communal commuting utilization.

Our study is subject to several limitations and possibilities. The study only focuses on two cities, Tbilisi and Warsaw, which does not represent all urban environments. Also, the analysis does not explore other potential variables that could affect bicycle commuting, such as city landscape or weather conditions. The research relies on self-reported data, which could introduce bias or inaccuracies.

Future research could expand the study to include more cities and diverse populations to provide a broader understanding of cycling behaviour. Qualitative research methods could complement the quantitative analysis by providing insights into the motivations and barriers to cycling. Collaborations with urban planners and policymakers could help translate research the findings into actionable strategies to promote cycling as a sustainable transportation option.

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