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Bike-Sharing Adoption in Cross-National Contexts: An Empirical Research on the Factors Affecting Users' Intentions

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Abstract: Due to the need to promote a larger scale of low-carbon commuting, it is important to identify the influencing factors of the users' intentions in the adoption of sharing bikes. For studying bike-sharing adoption in cross-national contexts, this research establishes a new model. By conducting multi-group structural equation modeling (SEM), the influencing factors of the adoption in China and Estonia are identified, respectively. Meanwhile, the moderation effects of the national context on several influencing factors are confirmed, and this result indicates that the contexts for bike-sharing adoption are different in the two countries. Two factors have also been found, namely the availability of infrastructure and the beneficial cost, for which policy interventions could have a significant impact in China but not in Estonia. Thus, more active policy interventions might lead to a higher level of adoption intention for the Chinese. This finding provides the implication that implementing policy interventions could be critical for accelerating the adoption of bike sharing and promoting low-carbon commuting.

Keywords: bike-sharing adoption; structural equation modeling; cross-national study

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1. Introduction

Environmental issues have caused significant concerns worldwide, and one concern is global warming due to greenhouse gas emissions [1,2]. To tackle this issue, reducing energy consumption and carbon emissions has become a commonly recognized strategy [3,4]. The transportation sector currently produces 23% of CO_2 emissions globally from fossil fuel combustion by motorized vehicles [5]. Furthermore, motorized vehicles are one of the major sources of environmental pollution in urban areas [6]. As motorized vehicles are still responsible for a considerable amount of pollution in many urban contexts, the development of alternative transport methods, such as public transportation and bicycles, has often been recommended [7]. Bike-sharing services are low in emissions; thus, by taking the place of motorized vehicles, the increasing adoption of bike sharing could decrease the use of high-emission vehicles in urban areas. Consequently, bike sharing is a green and sustainable transport choice due to its efficient use of resources and the reduction in harmful emissions [8]. In addition, bike sharing also brings many health benefits, while helping to improve the environment and quality of life for the users [9,10]. Hence, various bike-sharing systems have been implemented around the world to tackle global warming, reduce traffic congestion, and promote physical activity.

Promoting low-carbon commuting through deploying bike sharing worldwide is of great significance. Bike sharing has already gained in its initial popularity, and its emergence in different countries has been noticed. The bike-sharing program which was launched in Hangzhou in 2008 led to a mushrooming of the services across China. Similar programs can be seen in more than 100 cities [11], and the number of monthly active users of bike sharing at the beginning of 2017 was already around 10 million [12]. Currently, bike-sharing services in China are mainly provided by bike-sharing companies and have covered almost all cities in the country [11]. Compared with China, Estonia is a late comer in deploying bike sharing. The first bike-sharing program of the country was started in 2019

in its second largest city, Tartu, and consisted of 69 parking stations and 750 bicycles [13]; developing public transport, as well as non-motorized traffic, is a priority of the city. Besides, the circumstances of the city are also suitable for deploying bike sharing as the urban area of the city is covered with continuous non-motorized road network [14].

Meanwhile, different aspects of the initial popularity of the bike-sharing services are being noticed and pondered. On one hand, the adoption of bike sharing does relieve traffic issues to some extent in some areas. On the other hand, there are not enough active bike-sharing users, and motorized vehicles are still the dominant commuting modal in many places. To achieve reduced emissions in the transport sector, larger-scale bike sharing shall be implemented. There will exist various contributing reasons or factors behind the emergence of bike-sharing programs, and it is important to identify the potential factors influencing the users' intentions in engaging with bike-sharing programs so that tailor-made policies can be introduced by governments and bike-sharing companies to attract more active users and improve the bike-sharing adoption rates.

In the previous research base, various influencing factors of cycling adoption have been studied [15–20]. However, most of these influencing factors are studied without considering their interactions with each other. This research gap would be filled by comprehensively studying the influencing factors of the intentions in the newly established model.

Additionally, the contexts of the bike-sharing adoption in the different countries are not same, and the main influencing factors of the intention to use bike sharing in each country may differ. However, few cross-national analyses have been conducted. Therefore, Estonia and China were selected as the research objects in order to conduct a comparative study of the influencing factors of bike-sharing adoption. The reasons for choosing China and Estonia as research objects are the following: firstly, difference might exist between the collective culture in China and the Estonian individualistic culture of the West [21,22], and such difference might lead to different attitudes towards the new transit modal between two countries. It would be interesting to see how the influencing factors work in the contexts of the different cultures. Secondly, there are contrasts in geographical size and population as well as climate conditions between China and Estonia. For instance, the circumstances and scale of the Estonian cities could be different to those of the densely populated Chinese cities. As the country with the largest population in the world, China has seen a sharp increase in bike-sharing adoption in the last decade [12]. However, the case of deploying bike sharing in densely populated Chinese cities with a larger scale could be different to that of Estonian cities. Thus, these contrasts would be also interesting when studying the influencing factors of bike-sharing adoption. Thirdly, China started to promote bike sharing more than one decade ago and has already enjoyed recognizable success in bike-sharing adoption. For promoting bike sharing, many municipalities and bike-sharing companies have implemented various policies. However, as a latecomer in the promotion of bike sharing, Estonia just started its first bike sharing program in 2019 [13]. Biking has been the dominant transit modal in China since the last decade of the 20th century, and it is still an important transit modal in this country [23,24]. Different to the Chinese case, car culture is popular among Estonians, and cars are still the dominant transit modal in the country nowadays [25]. Due to the historical background of transit modal evolution, the Chinese may easily adopt bike sharing, whereas Estonians need to experience a dramatic transit switch to embrace the newly emerged modal. Thus, China and Estonia represent different stages of bike-sharing adoption, and they may go through different adoption processes. The above differences allow this research to make comparisons of the contexts of bike-sharing adoption between these two countries.

Hence, by identifying the research gaps, this research aims to comprehensively explore the influencing factors of the intention to use bike sharing and whether these influencing factors vary across different national contexts. To realize the aim, the following questions shall be answered in the research: (1) what are the potential influencing factors of the intention to use bike sharing? (2) Does the impact of the influencing factors of the intention to use bike sharing differ between Estonia and China? (3) What could be learned from the

potential differences of the impacts of the influencing factors between the two countries in order to more effectively promote bike-sharing adoption?

The survey was implemented from 25 October 2019 to 12 February 2020 in China and from 25 October 2019 to 5 March 2020 in Estonia, respectively. Finally, 232 valid questionnaires were obtained in China and 127 in Estonia. Multi-group structural equation modeling (SEM) is implemented in order to analyze the influencing factors affecting the users' intentions in bike-sharing adoption and their differences in cross-national contexts.

This paper is structured as follows: a literature review will be given in Section 2; the methodology will be presented in Section 3; the results will be discussed in Section 4; the discussions and conclusions will be presented in Sections 5 and 6, respectively.

2. Literature Review

The literature regarding the potential influencing factors is reviewed, and hypotheses on the relationships among the influencing factors, as well as the intentions, are made based on the literature review.

2.1. Habit Strength

It has been reported that past transit modes have had an influence on intention in the adoption of bike sharing [16,17], and a transit modal shift exists in the process of the adoption of bike sharing because once individuals decide to adopt bike sharing they will give up their former transit modal [11,26–29].

Habit strength largely dominates one's behavior with regard to switching from past transit modes. It has been reported that when an individual repeats a behavior and a habit has formed, he or she does not engage in a reasoned decision process each time but is guided by a cognitive process [30]. A corresponding finding shows that the intention to switch to public transport can be hindered by the habitual behavioral use of private vehicles, revealing the fact that habitual behavior may exert a negative influence on the reasoned evaluation process [15]. In other words, habitual behavior is not part of reasoned evaluation, which is the focus of traditional research in this field. The influence of habit strength on switching transit modal has been confirmed by different empirical research, and car-use habits can become an obstacle in deciding to use bicycles and public transport [31–34].

Biking used to be the dominant transit modal in China during the last decade of the 20th century [24]. Although a sharp increase in car adoption has been seen since the beginning of this century, the amount of car stock has not been dominant among various transit modals, and biking still plays an important role in the daily transit in this country [23]. Thus, people in China may easily embrace bike sharing which is similar with the biking they are familiar with. However, similar to other western countries, Estonia has a car culture, and cars are the dominant transit in the country [25]. Correspondingly, Estonians need to conquer the stronger habit strength to adopt the newly emerged bike sharing.

Therefore, hypothesis 1 is proposed as follows:

Hypothesis 1 (H1). *Habit strength negatively affects the intention to adopt bike sharing.*

2.2. Fast Mobility

As some scholars have argued, people adopt bike sharing because it provides fast mobility during the peak traffic times on weekdays [35]. It has been revealed that travel time affects the modal choice made by car users, and the evidence of improved individual mobility brought on by bike sharing has been found [36]. More densely established bike-sharing stations have been demonstrated to improve mobility [37,38]. Due to the benefit of fast mobility, it could be assumed that bike sharing may also affect the choices of the users of other transit modes. Therefore, hypothesis 2 is proposed as follows:

Hypothesis 2 (H2). *The perceived fast mobility positively affects the intention to adopt bike sharing.*

2.3. Exercise Function

Bike sharing also provides an additional exercise function when compared with motorized vehicles [18,19], and the exercise usefulness perceived by cyclists has been reported [39,40]. Therefore, people may pursue the function of bike sharing for reasons other than the transit benefits [20]. It is worthwhile mentioning that although bike-sharing bikes in Estonia also include electric motors, pedals are still retained for generating power; so, electric bike sharing in Estonia still includes the exercise function for cyclists. Among the bikes distributed in China, some are normal bicycles with pedals solely, whereas others are equipped with electric motors in addition to pedals. Therefore, bike-sharing bikes in both countries are purely or partially non-motorized vehicles. Thus, it is reasonable to assume that the exercise function of bike sharing could also be perceived by users, and hypothesis 3 is proposed as follows:

Hypothesis 3 (H3). *The perceived exercise function positively affects the intention to adopt bike sharing.*

2.4. Availability of Cycling Infrastructure

As it was reported, one important factor leading to higher cycling rates in Canada than in the United States is the setting of a separate cycling infrastructure, which leads to higher feelings of safety by Canadians [41]. Similarly, it is reported that sharing roads with trucks could severely impede people's intention to cycle [42]. Intercontinental research has also shown the strong impact of the existence of a cycle-friendly infrastructure on cycling adoption in northern Europe and North America as well as in China [43–46]. Differences in terms of establishing a cycling-friendly infrastructure also exist between Estonia and China. In China, non-motorized vehicles enjoy separate lanes to motorized vehicles and pedestrians. In particular, motorized vehicle lanes are separated from non-motorized lanes by metal fences. Whereas in Estonia, although cyclists are not forced to travel in the motorized vehicle infrastructure, they need to share infrastructure with pedestrians in most urban streets. This decreases cycling comfort and pedestrian safety and could also be a concern.

In addition to cycling lanes, it is also reported that the density of sharing bikes and their stations are critical to the adoption of bike sharing [47,48], and new bike-sharing stations increase member use [49]. Therefore, the following hypothesis is proposed:

Hypothesis 4 (H4). *The perceived availability of the cycling infrastructure positively affects the intention to adopt bike sharing.*

It is suggested that transport infrastructure development, including station-area planning as well as other subsidiary infrastructures, should be elevated as improving sustainable mobility and infrastructure development is especially critical in the initial stage of sustainable mobility transition [50]. More specifically, it is reported that the cycling infrastructure could enhance the mobility of cyclists [51]. Hence, it could be assumed that building the cycling infrastructure would have a positive influence on the cyclists' perceived fast mobility; thus, the following hypothesis is made:

Hypothesis 5 (H5). *The perceived availability of the cycling infrastructure positively affects the perceived fast mobility.*

A well-built cycling infrastructure could significantly improve people's willingness to do cycling exercises [52]. On one hand, additional cycling infrastructure could enhance the cyclists' enjoyment from cycling exercise; thus, cyclists could be more motivated to do cycling [53]. On the other hand, it is reported that the cycling infrastructure, including a cycling infrastructure could ease the safety concern of cyclists who pursue the exercise benefits of cycling, could enhance their interests in cycling exercise indirectly [54]. Hence,

it could be assumed that building a cycling infrastructure would have a positive influence on cyclists' perceived exercise benefits; thus, the following hypothesis is made:

Hypothesis 6 (H6). *The perceived availability of the cycling infrastructure positively affects the perceived exercise function.*

2.5. Perceived Beneficial Cost

The beneficial cost perceived by potential bike-sharing users is another influencing factor which shall be taken into consideration. In a broad case, Pan and Truong [55] draw a general conclusion that price is an important adopting determinant to low-cost carriers. Specifically, Yu et al. [22] confirmed the important role of the cost in bike-sharing adoption, and some bike-sharing programs enjoy more popularity than others due to their lower riding costs [11,56]. Due to the positive effect of the low cost of establishing bike sharing, lowering costs is regarded as an effective way to encourage the adoption of bike sharing. It is found that reducing the burden of the cost can remove adoption barriers to bike-sharing systems [57,58], whereas high costs may hinder people from adopting bike sharing [59].

Besides, it has been revealed that cost is one of the concerns when comparing different transit modes and is one determinant of transit modal choice [60–62]. Beyond the cost of bike sharing itself, the costs of other modes of transport may have an indirect effect on bike sharing adoption. Thus, hypothesis 7 is proposed as follows:

Hypothesis 7 (H7). *The perceived beneficial cost positively affects the intention to adopt bike sharing.*

It is found that lowering the costs of the products could elicit behavior change through the mediating of one's previous habits, and the effects of discount methods promoting people's new behavior are mainly through the inhibiting of their previous behavior [63]. Correspondingly, it is regarded that discounting provides the opportunity for people to rethink previous behavior habits and initiate the initial behavior change [64]. Hence, it could be assumed that lowering costs would inhibit the potential cyclists' habit strength regarding their previous transits, and the following hypothesis is made:

Hypothesis 8 (H8). *The perceived beneficial cost positively affects the habit strength.*

2.6. Environment Morality

One of the initial motivations for the active promotion of bike sharing in many countries is the deceleration of carbon emissions and the protection of the environment [65,66]. It has been reported that this is not only true for policy makers but some users of bike sharing also hold environmentalist beliefs [67–69]. However, not all bike-sharing users pursue such ideals, and the ratio of users with environmentalist beliefs varies from country to country [70,71]. In summing up the controversial research results in different national contexts, it can be seen that the role that environmentalism plays in public consumption behaviors varies in different countries. Therefore, it is reasonable to assume that the different roles environmentalism plays in different countries may also exist between Estonia and China. Thus, hypothesis 9 is proposed as follows:

Hypothesis 9 (H9). *The perceived environmental morality positively affects the intention to adopt bike sharing.*

2.7. Behavioral Intention

Behavioral intention refers to one's psychological tendency and motivation to do something [72]. For a more accurate measure behavioral intention, all interviewees should have riding experience with bike sharing. This is based on two concerns: firstly, only those who have ridden shared bikes can provide real answers based on personal experience and

more accurately measure the relationship between the influencing factors and the adoption intention; secondly, those who do not have riding experience may simply claim that they will adopt bike sharing but will not actually do so in practice. As reported by Chen [73], a significant difference exists between users and non-users in measuring the impact of the influencing factors of riding intention. In other words, bike-sharing users and non-users have a different perception of the potential influencing factors which influence their riding intentions, and it is necessary to distinguish between them when selecting interviewees. For measuring behavioral intention, two questions were adapted from Davis [74].

The hypothesized model with all direct and indirect effects is shown in Figure 1.

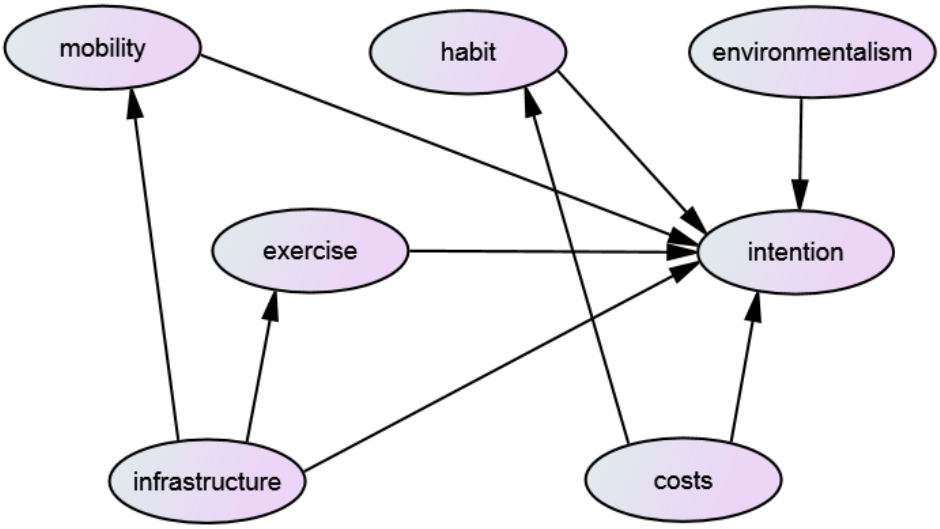

Figure 1. Hypothesized model showing direct and indirect effects.

2.8. National Context

The national context could moderate the impacts of the influencing factors on the users' intentions. As it was argued before, choosing China and Estonia as research objects was based on several reasons, and these reasons could be the possible aspects of the different contexts. Firstly, there is the potential difference between the collective culture in China and the Estonian individualistic culture of the West [21,22], which might lead to the two countries' different attitudes towards the new transit modal. Secondly, there are the contrasts in geographical size and population, as well as climate conditions, between China and Estonia, and they may lead to the different cycling rates in the previous research [75]. Thirdly, China and Estonia are in different stages of bike-sharing deployment, and the two countries may go through a different adoption process. Hence, in cross-national studies, potential differences in the contexts of bike-sharing adoption can be assumed between China and Estonia. That is, the national context may moderate the potential relationships between the users' intentions and their influencing factors. Thus, the following hypotheses are formulated:

Hypothesis 10 (H10). *The national context moderates the influence of habit strength on riding intention.*

Hypothesis 11 (H11). *The national context moderates the influence of fast mobility on riding intention.*

Hypothesis 12 (H12). *The national context moderates the influence of the perceived exercise function on riding intention.*

Hypothesis 13 (H13). *The national context moderates the influence of the availability of infrastructure on riding intention.*

Hypothesis 14 (H14). *The national context moderates the influence of the perceived beneficial cost on riding intention.*

Hypothesis 15 (H15). *The national context moderates the influence of environmentalism on riding intention.*

3. Methodology

Generally, for doing the empirical research, the data collection was firstly conducted and it was followed by analysis of the measurement model as well as hypothesis testing. The flow chart of research methodology is shown in Figure 2.

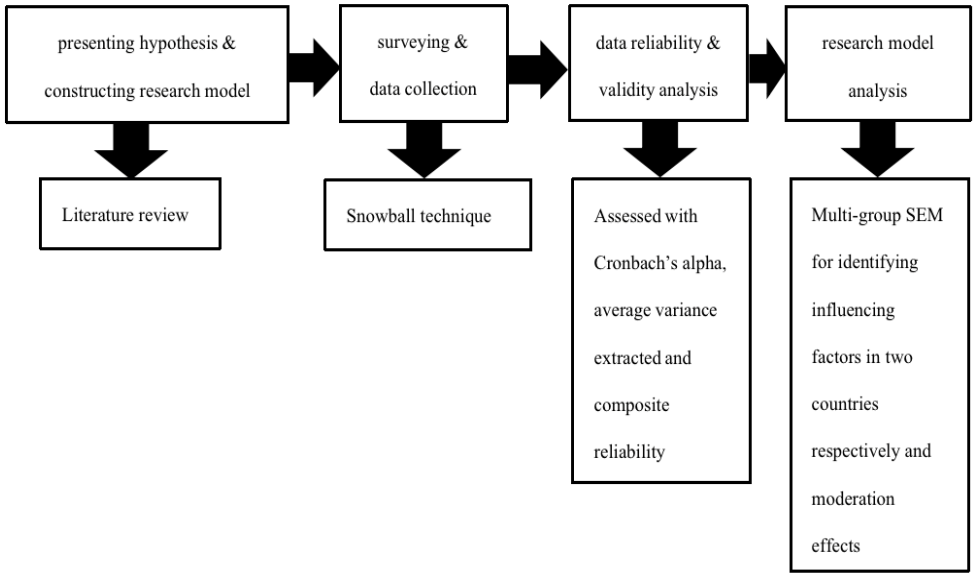

Figure 2. Flow chart of research methodology.

3.1. Data Collection

In this research, 27 questions were used and ranked on a seven-point Likert scale for data collection. Each factor contains three measurements and each question in the questionnaire is adapted from the relevant research literature for measuring the observed variable. The Likert scale starts with 1, meaning "strong disagreement", and ends at 7, indicating "strong agreement".

The questionnaires were digitally distributed in China and Estonia, respectively, and SPSS statistics 26.0 was used to document the collected data. The original questionnaire in English can be found in the Appendix A; it was translated into Estonian and Chinese, respectively, for surveys in Estonia and China. Therefore, the potential respondents in both countries would not have any obstacle to understanding the questions. In China, the survey was conducted from 25 October 2019 to 12 February 2020. In Estonia, it was conducted from 25 October 2019 to 5 March 2020. As difficulty was experienced in collecting sufficient respondents from the limited bike-sharing users, especially in Estonia, a specific data collection method needed to be used to alleviate this difficulty. The snowball sampling technique was adopted, with which a small group of people was initially contacted, and more connections were established through each initial contact person [76] (p. 765). Digital questionnaires were then sent to those having previous riding experience of sharing bikes and who were willing to fill in the questionnaires. Meanwhile, the request to contact more potential respondents who had used bike sharing were sent together with the questionnaires. For pooled data analyses, the variable called 'national context' was created. For labeling the variable, the Chinese respondents were coded with 0 and Estonian respondents were coded with 1. Finally, 232 valid questionnaires were obtained in China and 125 in

Estonia. The gender, age, and occupation of the respondents in the two countries are shown in Table 1.

Table 1. Demographic characteristics.

	Frequency		Ratio	
	EST	**CHN**	**EST**	**CHN**
Gender				
Female	67	121	53.6%	52.2%
Male	58	111	46.4%	47.8%
Age				
18–29	47	74	37.6%	31.9%
30–39	16	45	12.8%	19.4%
40–49	27	51	21.6%	22.0%
50–59	25	56	20.0%	24.1%
>59	10	6	8.0%	2.6%
Education				
<High school	0	15	0%	6.5%
High school	46	122	36.8%	52.6%
Bachelor	44	69	35.2%	29.7%
Master	32	23	25.6%	9.9%
Doctor	3	3	2.4%	1.3%
Occupation				
Public servants	8	66	6.4%	28.4%
Manufacturing workers	32	39	25.6%	16.8%
Administration	49	75	39.2%	32.3%
Business	26	33	20.8%	14.2%
Others	10	19	8.0%	8.2%

3.2. Analysis of the Measurement Model and Testing Hypotheses

Generally, the validity and reliability of the factors shall be analyzed and confirmed first, and model fitness will be checked during the analysis.

The validity of the measurement model needs to be confirmed to ensure the results of the hypotheses test. It is suggested that a two-step approach should be adopted for obtaining a good model fitness [77]. The reliability and validity of the factors in the model shall first be measured through Confirmatory Factor Analysis (CFA), and subsequently, the fitness of the model will be examined using structural equation modeling (SEM) while testing the hypotheses. SEM is one of the most widely used techniques by researchers in social sciences, and it can be used to conduct regression analyses between latent variables. By conducting SEM, the relationships between the theoretical constructs are represented by regression or path coefficients between the factors [78]. As the samples were collected from two different countries, they were divided into two groups and analyzed separately with multi-group SEM. The multi-group SEM test separates structural models into multiple groups, and multi-group models generally follow the same structure in each group and can provide separate estimates of the path coefficients and correlations within a group. Correspondingly, fitness indices can be obtained for each group separately [79,80]. The national context was adopted as the moderator to analyze its potential moderation effect on riding intention. The moderation effects were also tested by a multi-group SEM analysis to assess variations in the mediated and direct effects across the Chinese and Estonian samples. SPSS AMOS 22.0 software was used to conduct the multi-group SEM analysis.

Specifically, to determine the reliability of the data, Cronbach's alpha was calculated. Then, the validity of the data was measured by conducting Confirmatory Factor Analysis (CFA), in which the average variance extracted (AVE) and the composite reliability (CR) were calculated to examine each latent variable's convergent validity.

Following the examination of the validity of each latent variable, multi-group SEM was conducted to analyze the model hypothesis and check the model fitness. It is reported that CFI, GFI, NFI, and the NNFI are the most commonly used fitness indices for SEM

(McDonald and Ho, 2002). There is no agreement on which index is the best for assessing model fitness, and the most common way for dealing with this issue is to report a variety of indices as different indices reflect a different aspect of model fitness (Crowley and Fan, 1997). Hence, in this research Chi-squared, GFI (Goodness of Fit), NFI (Normalised Fitness Index), CFI (Comparative Fit Index), and RMSEA (Root mean square error of approximation) were applied.

The moderation effects of national context were tested with two steps. Firstly, if the coefficient of a factor in one group is significant while the other group's is insignificant in the group-based regression analysis, then the national context is regarded as having a moderation effect on this factor. Secondly, if the coefficients of the factor in both groups are significant, then the critical ratios for the differences between the path coefficients in the pairwise correlation analysis of the multi-group SEM analysis will be checked [81]. To be able to obtain the pairwise comparisons of the coefficients, the path coefficients from habit strength to intention were denoted as a1 in the Chinese model and a2 in the Estonian model. Accordingly, the path coefficients from fast mobility to intention were denoted as b1 and b2 in two models, respectively; from the exercise function, they were denoted as c1 and c2; from the availability of infrastructure to fast mobility, they were denoted as d1 and d2; from the availability of infrastructure to fast mobility, they were denoted as e1 and e2; from the availability of infrastructure to exercise function, they were denoted as f1 and f2; from the perceived beneficial cost to intention, they were denoted as g1 and g2; from the perceived beneficial cost to habit strength, they were denoted as h1 and h2; and from environmentalism to intention, they were denoted as i1 and i2. The critical ratios for the differences of path coefficients across the groups are the results of a z-test for the difference between coefficients from the Chinese model to the Estonian model. For a two-tailed test, a value of 1.96 is expected for the difference between paths to be statistically significant as $p < 0.05$. The moderation effects will be confirmed when the coefficient variance is significant.

4. Results

4.1. Analysis of Reliability and Validity

The values for Cronbach's α and composite reliability (CR), which indicate the reliability of a factor, are shown in Table 2. The values are beyond 0.9 for all factors in two models, and the results show satisfactory reliability for each factor. The values of average variance extracted (AVE) for the factors in two models are greater than 0.8, which is the lower limit of acceptable validity. Therefore, the results of both indicators fulfill the criteria, and they can be regarded as having sufficient convergent validity.

4.2. Analysis of Structural Equation Model

To assess model fitness, a variety of indices are reported to reflect the different aspects of model fitness. The obtained fitness indices are shown in Table 3, and the recommended value of each index is shown below the formulated value [82]. The results of the comparisons between all the obtained indices and their corresponding lower limit suggest that the model fitness is acceptable.

Table 2. Cronbach's alphas, average variance extracted (AVE) values, and composite reliability (CR) scores for validity and reliability analysis.

		CHN					EST				
	Observed Variable	**Loading Factor**	**Error**	**α**	**AVE**	**CR**	**Loading Factor**	**Error**	**α**	**AVE**	**CR**
Habit strength	HS1	0.848	0.080	0.970	0.931	0.976	0.892	0.014	0.988	0.968	0.989
	HS2	0.889	0.018				0.899	0.011			
	HS3	0.857	0.069				0.871	0.053			
Fast mobility	FM1	0.854	0.066	0.983	0.927	0.974	0.851	0.096	0.981	0.922	0.972
	FM2	0.798	0.014				0.902	0.033			
	FM3	0.872	0.103				0.865	0.064			
Exercise function	EF1	0.779	0.035	0.986	0.962	0.987	0.877	0.024	0.986	0.969	0.989
	EF2	0.791	0.011				0.893	0.018			
	EF3	0.770	0.026				0.870	0.032			
Availability of cycling infrastructure	ACI1	0.886	0.077	0.987	0.921	0.972	0.856	0.125	0.985	0.893	0.901
	ACI2	0.871	0.064				0.901	0.074			
	ACI3	0.879	0.055				0.877	0.077			
Perceived beneficial cost	BC1	0.851	0.076	0.978	0.917	0.970	0.832	0.150	0.971	0.879	0.956
	BC2	0.833	0.062				0.879	0.053			
	BC3	0.843	0.053				0.859	0.099			
Environment morality	EM1	0.774	0.037	0.996	0.945	0.981	0.833	0.081	0.972	0.929	0.975
	EM2	0.798	0.032				0.904	0.025			
	EM3	0.773	0.036				0.844	0.062			
Intention	I1	0.866	0.045	0.949	0.921	0.959	0.872	0.032	0.967	0.939	0.969
	I2	0.833	0.078				0.843	0.062			

Note: observed variables measuring habit strength, fast mobility, exercise function, availability of infrastructure, perceived beneficial cost, environmental morality, and intention are denoted as HS, FM, EF, ACI, BC, EM, and I, respectively.

Table 3. Fitness indices of structural equation model.

	CFI	**NFI**	**RMSEA**	**Chi-Square/d.f.**	***p***
CHN	0.951	0.943	0.089	4.321	0.000
EST	0.965	0.954	0.092	4.051	0.000
Recommended value	0.9	0.9	0.08	-	

4.3. Direct Effects and Indirect Effects

Figures 3 and 4 show diagrams of the path coefficients (unstandardized regression coefficients) of the hypothesized models of China and Estonia, respectively. Table 4 presents the unstandardized regression coefficients and standard errors of the two groups from the analysis result of SEM. In the Chinese model, except for insignificant environmental morality, the other direct impacts on intention have been confirmed by significant regression coefficients. The indirect impacts have also been confirmed: the effects of the availability of the cycling infrastructure on intention are mediated by fast mobility and the perceived exercise function; the effect of beneficial cost on intention is mediated by habit strength. Thus, the availability of infrastructure not only has a direct effect on intention, it could also indirectly influence intention through setting up impacts on the fast mobility and exercise function. Besides, beneficial cost, which has a direct effect on intention, can also indirectly affect intention through habit strength.

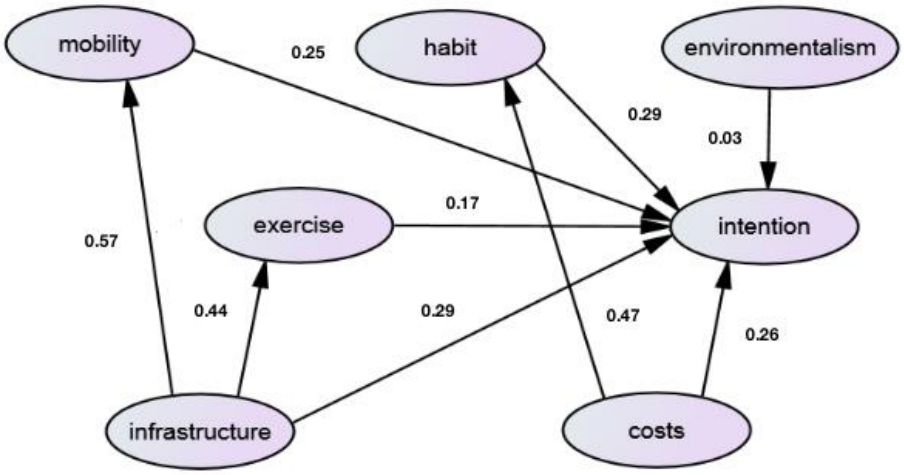

Figure 3. Diagram of path coefficients for the hypothesized model of China.

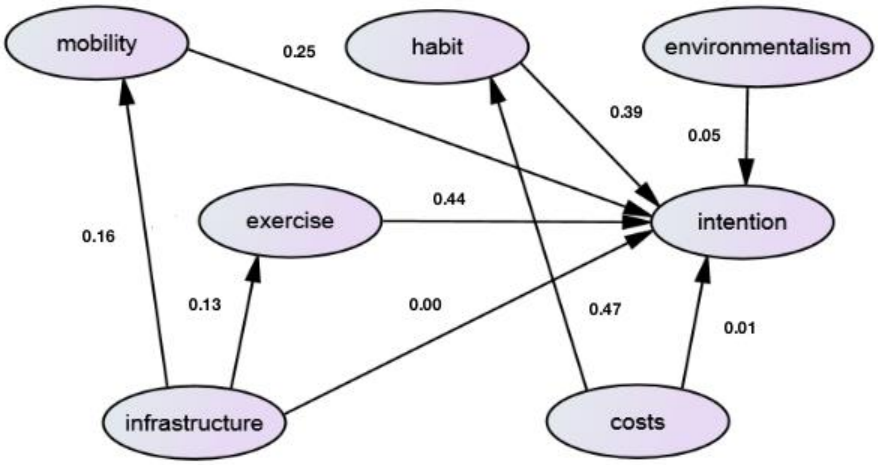

Figure 4. Diagram of path coefficients for the hypothesized model of Estonia.

Table 4. Unstandardized regression coefficients and standard errors of hypothesis tests using structural equation modeling.

Pathways of Influence	Unstandardized Regression Coefficients (S.E.)	
	CHN	EST
Direct effects		
habit strength → intention	0.291 (0.047) ***	0.385 (0.059) ***
fast mobility → intention	0.246 (0.030) ***	0.246 (0.051) ***
exercise function → intention	0.175 (0.037) ***	0.436 (0.069) ***
availability of infrastructure → intention	0.292 (0.038) ***	0.003 (0.043) n.s.
beneficial cost → intention	0.258 (0.040) ***	0.014 (0.056) n.s.
environment morality → intention	0.034 (0.023) n.s.	0.045 (0.064) n.s.
Mediated indirect effects		
availability of infrastructure → fast mobility → intention	0.139 (0.002) ***	0.039 (0.004) ***
availability of infrastructure → exercise function → intention	0.077 (0.002) ***	0.057 (0.004) ***
beneficial cost → habit strength → intention	0.136 (0.002) ***	0.180 (0.002) ***

*** $p < 0.001$, n.s. $p > 0.05$.

Similar to the Chinese model, the effect of environmental morality is also insignificant in Estonia. The direct effects of the availability of a cycling infrastructure and a beneficial cost, which are significant in China, are insignificant in this country. In contrast with the direct effect, the indirect effects of the availability of a cycling infrastructure on intention, which are mediated by fast mobility and the perceived exercise function, are significant. Thus, although the availability of infrastructure does not have a direct effect on intention, it could indirectly influence intention through setting up impacts on fast mobility and the exercise function. The same goes for beneficial cost, which does not have a direct effect on intention, but its effects can be indirectly transferred through habit strength.

By comparing the results of the Chinese model and the Estonian model, several differences shall be underlined and further discussed. It was found that the availability of infrastructure has a direct effect on intention in China, whereas it does not in Estonia. However, its indirect effects are significant in both countries. Similar results can be also found in the effects of beneficial cost, which are revealed by their contrasting direct effects between the two countries and significant indirect effects in both countries.

4.4. Moderation Effects of National Context and Contextual Differences

Table 5 shows the critical ratios for the differences of regression coefficients between the two models. For a two-tailed test, the critical ratios for differences between c1 and c2, d1 and d2, e1 and e2, f1 and f2, and g1 and g2 are greater than the absolute value of 1.96 for the difference between regression coefficients to be statistically significant at $p < 0.05$. The following pathways are moderated by national context: perceived exercise function on intention, availability of infrastructure on intention, beneficial cost on intention, availability of infrastructure on fast mobility, availability of infrastructure on perceived exercise function, and beneficial cost on habit strength. In contrast, the pathways of habit strength on intention, fast mobility on intention, and beneficial cost on intention are not moderated by national context.

Table 5. Critical ratios for differences of regression coefficients between two models.

	A1	**B1**	**C1**	**D1**	**E1**	**F1**	**G1**	**H1**	**I1**
A2	**1.270**	2.033	2.911	1.298	−1.949	−0.623	1.689	−2.625	5.273
B2	−0.586	**0.021**	1.140	−0.701	−3.761	−2.579	−0.165	−4.584	3.765
C2	1.783	2.531	**3.332**	1.833	−1.347	−0.020	2.183	−1.894	5.510
D2	−4.483	−4.630	−3.004	**−5.034**	−7.029	−6.345	−4.169	−8.918	−0.636
E2	−1.485	−1.098	−0.184	−1.615	**−4.101**	−3.091	−1.165	−4.948	1.637
F2	−2.172	−1.831	−0.648	−2.408	−5.002	**−4.011**	−1.182	−6.243	1.633
G2	−4.054	−4.051	−2.607	−4.499	−6.630	−5.869	**−3.736**	−8.288	−0.366
H2	−1.354	−0.940	−0.940	−1.486	−4.063	−3.025	−1.019	**−4.956**	1.948
I2	−3.053	−2.829	−1.738	−3.305	−5.587	−4.704	−2.744	−6.746	**0.158**

Note: Critical ratios which are actually used for identifying differences of two models' regression coefficients are marked in bold.

5. Discussion

5.1. Influencing Factors of Bike-Sharing Users' Intention

In agreement with the previous research, this study finds that habit strength, fast mobility, exercise function, and beneficial cost have significant impacts on the adoption intention in both countries [16,17,20,22,36,38,47,48]. In contrast with the findings that bike-sharing riders hold environmentalist beliefs [67–69], environmental morality does not have a significant impact in either of the two countries. Besides, the availability of infrastructure and the beneficial cost have an effect only in China, whereas they do not in Estonia. It has also been noticed that the availability of infrastructure and the beneficial cost play a critical role in influencing adoption intention in China because they not only have direct impacts on intention but also have indirect effects on intention as mediated by other factors. The effects of the availability of infrastructure on intention are mediated by fast mobility and the exercise function; thus, the availability of a cycling infrastructure

could indirectly influence intention through these two influencing factors. The above findings suggest that the perceived fast mobility and the perceived exercise function could be enhanced through improving the cycling infrastructure, and adoption intention could also be strengthened by doing so. However, the context is different in Estonia and the availability of infrastructure does not have an indirect impact on adoption intention in this country because the mediated effects of fast mobility and exercise are not significant. Thus, neither the direct impacts nor the indirect impacts of the availability of infrastructure function on intention have been found in Estonia. For the perceived beneficial cost, it could indirectly influence intention being mediated by habit strength in both countries, and this suggests that habit strength, which impedes adoption intention, could be alleviated through lowering the costs of riding shared bikes. Thus, the perceived beneficial cost has direct and indirect impacts on intention in China, whereas it has only indirect impacts on intention in Estonia.

5.2. Moderation Effects and Contextual Differences

The moderation effects of the national context are confirmed by the pairwise comparison of regression coefficients across the two models, and this suggests that the contexts of bike-sharing adoption are different in the two countries.

It is revealed that the different impacts of the perceived beneficial cost between the two countries could be due to the difference of the ratio between the cost per bike-sharing ride and the average income, which is a reflection of the relative cost of a ride. By calculating the cost per ride to a monthly income ratio of the two countries, respectively, it was found that the ratio in Estonia was almost double that of China. This indicates that bike-sharing riding is significantly more expensive in Estonia, and this lowers their perception on the beneficial cost in relation to bike sharing.

The significant impact of the availability of a cycling infrastructure has only been seen on the intentions of the Chinese and this reveals that Estonians are not as satisfied with the cycling infrastructure as the Chinese when considering bike sharing. The variance of satisfaction on the cycling infrastructure might be due to several reasons. Firstly, the lower satisfaction might be due to the lack of a separated cycling infrastructure on most urban roads. The findings also correspond with the conclusions of previous studies, where the existence of separated cycling infrastructure and a high density of shared bikes and their stations in China were seen to contribute to people sensing strong urban cycling friendliness [11,38]. Secondly, the increasing density of sharing bikes in urban area helps the promotion of bike-sharing deployment [47,48], and the possibly different density of bike-sharing bikes may also explain why Estonians perceive the availability of cycling infrastructure differently. However, detailed evidence on the density difference of bike sharing between China and Estonia is currently absent; therefore, it cannot be confirmed whether the differences in perception on the availability of cycling infrastructure are led by the density of bike sharing between the two countries.

5.3. Implementation of Policy Interventions

This study indicates several implications emerging from policy interventions on the various influencing factors of the intention to use bike sharing.

Although the moderation effects of national context were found on several pathways, that of the availability of infrastructure on intention and beneficial cost on intention are especially interesting. It is found that the direct impacts of the availability of a cycling infrastructure and beneficial cost, which could be affected by policies, are significant in the Chinese context, whereas neither of them is significant in the Estonian context. Besides, the mediated effects of the availability of infrastructure on intention are significant in the Chinese context, whereas they are not in the Estonian context. This finding indicates that different policy implementations may be related with the different impacts of the two influencing factors across the two countries.

It is reported that different policies regarding lowering riding costs have been implemented for promoting bike sharing in China, and various municipal governments have devised different promotional policies that deliver an economic bonus to potential bike-sharing riders. For instance, the municipal government of Hangzhou introduced a policy which lowers the cost per ride for those who sign up for an annual membership of its public bikes program [11]. Therefore, it is likely that the more active policies regarding lowering riding costs in China have led to the significant impact of beneficial cost on riding intention, as the Chinese are more motivated by the relatively lower costs of riding shared bikes.

Various policy interventions lowering the costs of riding shared bikes have been implemented in China and the stronger effects of the perceived beneficial cost in the country could be led by more active monetary policy interventions. In response, policy interventions aimed at lowering riding costs could also be implemented in Estonia to enhance people's perceived benefit cost and further strengthen their intention to ride shared bikes. These policy interventions can be municipal subsidies to bike-sharing programs, bonus packages, and memberships offered by bike-sharing firms.

The difference in impacts of the availability of a cycling infrastructure implies that separate cycling lanes and a greater density of bike sharing should be established to achieve the similar adoption level as in China. Importantly, it shall be kept in mind that the establishment of a cycling infrastructure is implicitly correlated with policies because only through policies regarding planned infrastructure are the establishments of cycling infrastructure being implemented. Thus, the impact of the availability of a cycling infrastructure could be intervened by policies, and the different perceptions on the availability of infrastructure in the two countries might be due to different previous policies regarding the establishment of a cycling infrastructure.

Active policies regarding the cycling infrastructure establishment in China led to a satisfactory cycling infrastructure, and it could be responsible for the significant impact of the availability of cycling infrastructure on user intention. In response to this finding, it is suggested that policy instruments regarding the establishment of a cycling infrastructure and more shared bikes, as well as stations, be implemented to strengthen the perceived availability of the cycling infrastructure in Estonia.

6. Conclusions

This research aims to identify the influencing factors of user intention in regard to bike sharing and to test the potential differences of the cross-national contexts. Various potential influencing factors are constructed in the model for comprehensively describing the riding intentions of bike sharing. The empirical analysis finds that habit strength, fast mobility, exercise function, and beneficial cost have significant impacts on adoption intention in both countries. However, environmental morality does not have a significant impact in either of the two countries, and the availability of infrastructure as well as beneficial cost have a direct effect on intention only in China, whereas they do not in Estonia. Besides, the mediated effects of fast mobility and exercise are significant in the impacts of infrastructure on intention in China and thus the indirect impact of availability of infrastructure on adoption intention in this country, whereas similar mediated effects are not found in Estonia. Hence, neither the direct impacts nor the indirect impacts of the availability of the infrastructure function on intention have been found in Estonia. The perceived cost benefits could indirectly influence intention being mediated by habit strength in both countries. Thus, the perceived beneficial cost has direct and indirect impacts on intention in China, whereas it has only indirect impacts on intention in Estonia.

The moderation effects of national context on the influences of the availability of infrastructure and beneficial cost on riding intention have been confirmed. The moderation effects are revealed by the different impacts of the two influencing factors on riding intention between China and Estonia. Specifically, a significant impact of the availability of cycling infrastructure on intention is found in China, whereas it is insignificant in Estonia. Meanwhile, beneficial cost has a much stronger impact in China than it does in Estonia.

The moderation effects of national context reveal the contextual differences of bike-sharing adoption between the two countries. Although bike sharing has seen successful in China over the last decade, the same story could not be expected to be simply copied in Estonia.

This research has led to two theoretical contributions by filling the previous research gaps. Firstly, this study establishes a new model for studying the impacts of various potential influencing factors on bike-sharing adoption. Previous research individually studied the influencing factors of the intention to use bike sharing without being comprehensively studied in a model framework. The newly established model provides a more in-depth understanding of the characteristics of bike-sharing adoption. Secondly, this research completes a cross-national comparative analysis of bike-sharing adoption. Although the contexts of bike-sharing adoption in different countries may differ, previous research tended to limit the study range within a single country. It is reasonable to take potential differences between different countries into consideration, and the current research calls for more cross-national analyses. It is anticipated that comparative analyses involving a wider range of countries in relation to bike-sharing adoption can be conducted in the future.

There are several limitations in this research. Firstly, due to the considerable sampling bias and margin of error in the snowball sampling technique, the results cannot be representative of a wider population. This technique has several significant drawbacks that decrease the relevance of the research in a wider context. Secondly, the reasons that lead to the different impacts of habit strength between the two countries are still unknown, and it might be the difference between the collective culture in China and the individualistic culture in Estonia. However, it is difficult to measure cultural perceptions of the respondents, and it would be beyond the work of this research. It would be useful to confirm the existence of cultural differences in moderating bike-sharing adoption in the two countries, as policy implementation could be affected by them as well.

The practical implications regarding policy implementation are brought by this study. As more active policy interventions in China might be responsible for the differences, some lessons regarding policy interventions can be learned by Estonian policy makers from the Chinese experience, and various types of policy interventions targeting the infrastructure establishment and riding cost reduction can be implemented to strengthen the adoption intention of bike sharing.

This research provides an initial blueprint for understanding the adoption of policy interventions on bike-sharing adoption. That is, the detailed mechanisms of the influence of different types of policy intervention should be studied in future research. Through understanding the specific mechanisms of these policy instruments, they can be revised and updated to maximize their impact. Recent studies also found that people have switched more to use sharing bikes during the COVID-19 time [83–85], although these times might be temporary, as the pandemic will be over at some point; it is still necessary to have a better understanding of what affects people in these decisions in the future.

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Appendix A

Constructs	Questionnaire Items
Habit strength	The habit of using previous transit modal has impacts on using shared bikes
	I need to conquer the transit habit of the previous modal for using shared bikes
	I did think about keeping the previous transit habit before using shared bikes
	Questions adapted from [34,86]
Fast mobility	Fast mobility increases my intention to use shared bikes
	Fast mobility is one of the advantages of riding shared bikes
	I ride shared bikes to pursue the benefit of fast mobility
	Questions adapted from [35,36,38]
Exercise function	I use shared bikes to pursue the benefit of their exercise function
	The benefit of the exercise function is important for increasing my willingness to use shared bikes
	I see the exercise function as one of the benefits shared bikes can bring to me
	Questions adapted from [18,19]
Cycling infrastructure	The availability of cycling infrastructure can comfort my safety concerns on riding shared bikes
	The availability of cycling infrastructure can decrease the difficulty of riding shared bikes
	I see availability of cycling infrastructure as one of aspects of the ease of riding shared bikes
	Questions adapted from [41,44,46]
Beneficial cost	Riding cost is one point that motivates me to ride shared bikes
	The cost of using shared bikes may increase my willingness to use them
	Reasonable cost is important for me to ride shared bikes
	Questions adapted from [56]
Environmental morality	I think protecting the environment is what I should do
	I think protecting the environment is in accordance with morality
	I am concerned with whether my transit modal is environment friendly
Questions adapted from [68]	
Intention	Assuming I have access to shared bikes, I intend to use them
	If I had access to shared bikes, I predict I would use them
	Questions adapted from [87]

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