



Article

# Aspects of E-Scooter Sharing in the Smart City

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**Abstract:** The contemporary urban environment faces such challenges as overloaded traffic, heavy pollution, and social problems, etc. The concept of the “smart city” allows solving some of these issues. One of the opportunities provided by the smart city is the development of micro-mobility and sharing services; contributing to the optimization of transport flows and decreasing carbon footprints. This study investigates the factors affecting the development of e-scooter sharing services and the attitudes of young urban residents towards using these services. The research applied a PLS-SEM (partial least squares structural equation modeling) analysis performed in SmartPLS3.7 software. The data were collected via focus groups and surveying a population aged 18–35. The authors partially based the research on the UTAUT model (the unified theory of acceptance and use of technology), taking such constructs as “intention to use”, “anxiety”, “attitude toward use”, “effort expectancy”, and “social influence”; they also introduced the new unique variables “internal uncertainty”, “e-scooter design”, “experience”, “perceived safety”, “infrastructure quality”, and “motivation to physical activity”. The main finding of the study was determining that the latent variables attitude towards sharing, anxiety, internal uncertainty, JTBD (jobs to be done), and new way of thinking have a direct or indirect effect on the intention to ride e-scooters in the future and/or to use sharing services. The obtained results permit making recommendations to businesses, municipal authorities, and other stakeholders on developing e-scooter sharing services as a contribution to the advancement of the smart city.



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**Keywords:** smart city; micro-mobility; e-scooter sharing; PLS-SEM in SmartPLS; influencing factors; barriers to e-scooter sharing; JTBD

## 1. Introduction

The time of the COVID-19 pandemic is a time of changes. Many concepts come to life, develop, change, and go away. New phenomena are becoming the center of attention of scholars, society, authorities, and producers. Micro-mobility, not new in its essence, received special attention, due to some specific factors specific to the contemporary global world, which simultaneously disintegrated as a consequence of the pandemic.

Issues of sustainability, traffic planning in big cities, people’s new ways of thinking, and increased requirements towards the urban environment, etc., have become challenges for contemporary cities, and smart city solutions can contribute to solving many of these urban issues. One of the ways of solving these problems is the development of micro-mobility and sharing services within the framework of smart city advances.

Micro-mobility is assumed to be fairly new and innovative modern mode of urban transportation, capable of decreasing trips by private transport (especially first- and last mile trips); improving the ecological situation in the city; introducing a healthier life style, due to the lower emissions from private cars; and increasing the quality of life, due to provision of more mobile, flexible transportation means, which are cost-efficient and easily available; and this is not a full list of the contributions of micro-mobility to the development of a smart city [1–4].

There are many researches devoted to the various types of micro-mobility, but e-scooters as a means of transportation are a rather new option, and, although, there is research on this type of transportation, nevertheless, there is still a certain lacuna in the vision of the future development of this type of micro-mobility in smart cities.

Therefore, the authors believe this study can contribute to comprehending the factors influencing the development of e-scooter services, including their sharing prospects. This is especially urgent, taking into consideration that people are the most significant part of almost all processes in smart city, and that their attitudes, opinions, way of thinking, education, and experience become the factors allowing the solving of the contemporary tasks of the smart city [5–7].

The creation of a smart city requires substantial investments, and understanding the factors impacting the introduction of solutions in life, and further active exploitation of these solutions by citizens, requires serious study of human behavior, otherwise these investments in smart solutions will not be effective and efficient.

The goal of this research was to determine the most significant factors affecting the behavior of consumers regarding the use of e-scooter sharing services

This type of micro mobility is rather new to European cities; it has appeared in active use in Europe only in recent years [8,9], and has attracted a lot of attention.

This issue is of great practical importance for Riga, Latvia. Latvia is a country of the Baltic Sea Region, it belongs to the group of Central and Eastern European Countries (CEEC), and has certain issues requiring special attention in its development. It has a high level of technological advancement [10]; the capital city Riga has the status of a smart city and takes the 96th position in the world list of smart cities, and the 34th place in the European list of smart cities [10,11].

Therefore, the promotion of various types of micro-mobility and sharing services will contribute significantly to further the development of Riga as a smart city.

The local authorities have made significant investments in creating special infrastructure for micro-mobility (EUR 16.5 million in 2021), and the reaction of citizens was rather negative, considering the narrow streets of the city, the general traffic flows, and the habits and behavior patterns of the population [12–15].

Therefore, the lack of research on the preferences and behavior patterns of the population became substantial problems for the city authorities. Thus, we suggest that this study can make a real contribution to modelling the special infrastructure for micro-mobility in Riga.

The authors did not consider the development of all types of micro-mobility within smart city; we studied only the attitudes of people towards such smart solutions as the introduction of standing e-scooters on the streets of the city, and considered different types usage: using sharing services or ownership.

The authors use the term “e-scooter” as an abbreviated form of “standing e-scooter”, although in many other research works we can find other names for this micro-mobility mode.

The attitude of citizens toward riding e-scooters and using sharing services was investigated with employment of structural equation modeling (SEM). To analyze the data in this study, the authors chose PLC-SEM (partial least squares structural equation modeling) over CB-SEM (covariance based structural equation modeling). Choosing the PLS-SEM type of analysis is explained, first of all, by the fact that this research is oriented toward exploratory purposes, rather than testing already existing theories [16–22]. A more detailed description of PLS-SEM and CB-SEM (covariance based structural equation modeling) analysis is presented in Section 3.2 (Methods: development of the framework of the model and formation of hypotheses).

## 2. Literature Review

A smart city is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses [10,23,24]. The constituent parts of a smart city include the smart economy,

smart people, smart living, smart mobility, smart governance, and smart environment. There are specific challenges to all these areas, and part of these challenges can be reduced and mitigated by micro-mobility [25]. This study reveals the factors, directly and indirectly affecting the intention to use and share micro-mobility; the analysis is done with the employment of PLS-SEM analysis.

Another part of the smart city and smart economy is sharing. According to [26], the sharing economy is known under many names; for example, collaborative economy, collaborative consumption, access economy, platform economy, community-based economy, and so on. A sharing economy results in the better allocation of resources, since underutilized assets are shared, and it contributes to the smart city concept, as well as to sustainability [10,27]. The sharing economy creates common values in many spheres of life [28].

Mobility has changed significantly over time; nowadays it is a new paradigm, which has new approaches to the movement of people and freight, considering these flows, not only from a technical position, but also from the social point of view. This is closely connected with all the new phenomena governing our life: globalization, communication technologies, migration, etc. [29].

Micro-mobility is one of the areas employing the multi-folded concept of mobility. The micro-mobility topic is not very well developed; however, there are many studies investigating the various sides of it. To begin with, there is no strict definition of micro-mobility as an event in urban life. In this research the authors use the following definition: micro-mobility can be defined as trips of short distances, with employment of light and small-sized vehicles. It is assumed that these vehicles are powered by electricity (e-devices) or man power (bikes, kick scooters), and speed does not typically exceed 45 kph. It is a promising solution for transport in urban areas, and oriented toward short-distance and also first and last mile trips [1,25].

The concepts of sharing and micro-mobility can be easily combined. Shared micro-mobility assumes access for short time to this transportation mode on an “as-needed basis” [30]. Shared micro-transport can improve the life of the urban population, increase “environmental awareness” (in this study this indicator is included in a wider concept “new way of thinking”), can contribute to quality of life [30], and, thus, promote the development of the smart city.

Nevertheless, if the city residents do not want to use micro-mobility for riding in the streets, this concept will not be viable. It is very important for all stakeholders to comprehend what factors are taken into consideration by the people when they make a decision to ride or not ride an e-scooter. One of the wide-spread models for determining the attitudes of a population towards technologies is the UTAUT model (the unified theory of acceptance and use of technology) [31–35]. This model does not fully correspond to the needs of this research; however, it could serve as a basis for creating a model suitable for this study. Therefore, it was necessary to determine the factors that could be included in the model. The Table 1 below shows which factors impacting micro-mobility were considered by other researchers.

**Table 1.** Review of factors affecting micro-mobility within the scientific literature.

Investigated Factors	Authors
Gender	[36–42]
Age	[38–44]
Education	[38,41–45]
Marital status	[37,44,45]
Employment	[41,43]
Race/Ethnicity	[37]
Income	[37,40–46]

Table 1. Cont.

Investigated Factors	Authors
Place of residence (city center, suburb, university campus)	[39,40,45–47]
Population density	[46,48]
Rider satisfaction factors (battery capacity, customer service, ease of use pricing, safety (speed), safety (technical), e-scooter age, ease of use)	[36]
Demand-stimulating activities (daily meals/drinks, shopping and entertainment)	[49]
Urban landscape, characteristics of the area (parks, special zones, places of skiing, population density, business districts, land use)	[27,40,44,46,48–50]
Places of use of e-scooter (city center, university campuses, business districts)	[42,47–49]
Density of attractions	[48]
Forecast of future use of e-scooter	[37]
Niche for e-scooter	[51]
Switching to e-scooter from a car	[52]
Demand for e-scooter (potential demand, factors of increasing demand, demand forecast)	[44,46,47,51]
Frequency of demand	[41,46,48,51]
Frequency of use	[39,40,42–44,52]
Travel time	[41,42,52,53]
Using a bicycle and car sharing	[41,45]
Replacement of other transportation modes by e-scooter (car, any personal transport, public transport, taxi)	[37,39,40,44,53]
Competition and comparison with other micro-mobile vehicles (bicycle)	[53,54]
Combination with other transport	[39]
Ownership or use of other vehicles (car, e- and regular bike, motorcycle)	[43,45]
Road infrastructure and recharging facilities	[46,51,53,54]
Road surface	[39,54]
Parking lots	[39,46]
Weather	[41,53,55]
Scooter design (luggage transportation)	[45,53]
Purpose of use (short trips, direct trips, entry/exit trips, the “last-mile” problem, entertainment, recreation, combined trips, trips to work/study, communication with close people, replacement of walking)	[37–40,43,44,49,53,56]
User behavior	[40,47]
Environmental awareness	[45]
User groups	[39]
Motivation factors, advantages of traveling by e-scooter (faster, more convenient, more fun, easier, cheaper)	[37,40,41]
Rider training, information support (security aspects)	[39,57]
Legislation and governance	[40,53]
Safety (wearing helmets, aggression of drivers, speed limit, road surface, road signs)	[39,40,45,53,58]

**Table 1.** *Cont.*

Investigated Factors	Authors
Perceived safety	[37,59]
Conflicts arising around e-scooters	[39,53]
Accident rate (injuries, treatment costs, risk of accidents)	[41,60,61]
Solving urban problems (traffic jams, ecology, enriching urban mobility)	[53,62,63]
Barriers (disinterest, lack of e-scooter presence, security, feeling of instability, worry about falling, price, weather, infrastructure, battery capacity, luggage carrying, public opinion, road surface, aggression of car drivers, long distances)	[37,39,42,53,59]
Reasons for not riding e-scooters (infrastructure, price, limited quantity)	[39]

Source: generated by authors.

### 3. Materials and Methods

#### 3.1. Data Collection

This research started with a preliminary study aimed at determining the constructs of the model and their indicators. For this purpose, the authors interviewed 13 respondents and used four focus groups of five people and found out the opinions of young residents of Riga (18–35 years old,  $22.83 \pm 3.83$ ) about using e-scooter sharing services. (The data in this research are presented in the form of mean  $\pm$  standard deviation).

The participants were people who already had experience in riding an e-scooter (60.87%,  $n = 14$ ), and people without such experience (39.13%,  $n = 9$ ). The goal of this study was to determine the factors affecting the decision to share e-scooter services and to develop these services; therefore, the authors were interested in the opinions of both categories of people: those who use e-scooters for trips around the city, and those who do not use them. It should be noted that the respondents who participated in the preliminary study were not involved in the questionnaire, in order not to create a threat to validity due to the testing effect.

The authors developed the constructs for the model (see Section 3.2, describing the model); the constructs were built on the basis of the preliminary research and literature review (see Table 1).

After determining the constructs of the model, the questions for the survey were formulated and the target group of respondents determined. A questionnaire of 42 questions was developed, presupposing the answers according to a 5-point Likert scale: (1) strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree [64]. Taking into account the negative attitude of some residents, including the citizens of Riga, towards e-scooters, we used semi-closed questions, oriented toward the opportunity for respondents to express their negative opinion in the “other” field, and not refuse to answer the questionnaire. The target audience of this study was young residents of Riga, aged 18–35 years, since, according to the published data, the main e-scooter users are young people of this age category [65,66].

A test study, based on the answers of 17 respondents, was conducted. This helped to improve the questionnaire, so that all questions and answers were unambiguously and adequately understood by the respondents.

The questionnaire was distributed electronically among the students and the graduates of the universities and colleges in Riga, as well as among young entrepreneurs and employees of several companies. It should be noted that the respondent could not submit an e-questionnaire if there were not answers to all the questions; as a result, only fully completed questionnaires appeared in the database. All the questions were direct. There were no indirect, suggestive, or tendentious questions or answers. This questionnaire does not affect the sensitive aspects of respondents, and the answers to the questions cannot

affect their lives. Therefore, the probability of deliberate inaccuracy in the respondents' answers was very low. In order to minimize possible research errors in the formulation of questions, first, we used simple expressions; second, we focused on similar questionnaires in the published studies by other scholars; and third, we used data from focus groups and then preliminarily tested them.

When 365 questionnaires without missing questions were collected, the process of collection was stopped. As a result, 194 (53.15%) male and 171 (46.85%) female respondents aged 18–35 years participated in this study, the average age with standard deviation was  $27.35 \pm 3.79$  years.

Next, the process of analyzing the interrelation started. According to the hypotheses, the study involved the analysis of 21 relationships. The “ten times rule” [67], an inaccurate and criticized, but simple, method for determining a sample size, says that in such a study 210 valid surveys are needed for representativeness, which is less than the samples obtained. A much larger number of answers were collected, so that there was an opportunity to explore non-intended relationships.

### 3.2. Development of the Framework of the Model and Formation of Hypotheses

The scholars mainly used two approaches to structural equation modeling (SEM) for simultaneous analysis of several statistical relationships: partial least squares structural equation modeling (PLS-SEM) and covariance based structural equation modeling (CB-SEM) [17,68,69].

SEM is used to investigate relationships between latent constructs (latent variable), consisting of measurable observable variables (indicators), and tested on reliability [17,68–70]. CB-SEM refers to the common factor-based SEM method; it considers constructs as common factors [69]. CB-SEM is usually used to verify and confirm an already existing theory, when it is necessary to investigate the conformity of the model and the correctness of the choice of factors. PLS refers to the composite-based SEM method, where a linear combination of indicators is used for composite variables [69].

PLS-SEM is a technique that allows a good causal-predictive analysis and explaining the variance in the independent constructs [68,69]. PLS-SEM combines a regression-based path analysis and analysis of the most important components [71] and permits forecasting the behavior of a peculiar construct [72]. In addition, this technique is applicable for specifying the mediating and moderating effects, and showing direct and indirect relationships [70]. In general, this method is preferred by many scholars working in innovative areas [18,73,74].

In cases where a researcher is interested in developing a theory, constructing explanations, and forecasting the indicator's behavior, PLS-SEM is more suitable. In general, this method is preferred by many scholars working in innovative areas [18,73,74].

The PLS-SEM method considers an inner and outer model. The inner model refers to the relationships between independent and dependent latent variables, while the outer model considers the relationships between the latent variables and their observed indicators. Latent variables are the variables that are not directly measured; they are commonly called constructs.

When determining the model constructs that could potentially have implications for ES sharing, we focused on the research conducted by the author and on the components of the unified theory of acceptance and use of technology (UTAUT) [30–32,34,35].

The UTAUT principle, especially its extended version, is a method well suited for various fields [31,75], including micro-mobility; for example, bicycle sharing [76]. As a result, we came to the conclusion that e-scooter sharing (the Sharing construct) can be defined by the following groups of constructs:

1. Attitude towards e-scooter sharing (attitude towards sharing, *Att*),
2. In general, the intention to use the ES in the future (intention to use in future, *Int*),
3. Fear of using the e-scooter (anxiety, *Anx*),

4. Internal uncertainty regarding movement on micro-transport and the e-scooter (internal uncertainty, *IU*),
5. Having experience in e-scooter riding (experience, *Exp*),
6. The users' demand for the functions performed by the e-scooter (jobs to be done, *JTBD*),
7. Attitude towards the safety of this type of transport, (perceived safety, *PSaf*),
8. Quality characteristics of the roads (infrastructure quality, *Infr*),
9. Effort expectation (*EE*),
10. e-scooter design features (design, *Des*),
11. New way of thinking (*NEW*),
12. Social influence (*SI*),
13. An active and healthy lifestyle, and the use of an e-scooter to implement it (activity, *Act*).

The corresponding indicators were identified for each construct (see Table A2 in the Appendix A). Based on the identified constructs, the framework of the theoretical model was formed, and the research hypotheses were developed. The theoretical model describes the causal relationships, assessing the influence of various factors for the intention and use of sharing.

The attitude of consumers towards the sharing and the intention to use something in the future, according to the theory [30–32,34,35] can have a significant impact on its use. This assumption became the basis for H1 and H2:

**Hypothesis 1 (H1):** *In general, the intention to use the e-scooter in the future (intention of future use, Int) has a direct positive impact on the use of sharing for various purposes.*

**Hypothesis 2 (H2):** *A positive attitude towards e-scooter sharing (attitude towards sharing, Att) has a direct positive impact on the use of sharing for various purposes.*

The use of any vehicle is often associated with anxiety. It is very important to understand which factors prevent citizens from using e-scooters. Therefore, the model estimates the impact of anxiety on the constructs intention of future use and sharing (H3):

**Hypothesis 3 (H3a,b):** *Consumer's anxiety (Anx) directly negatively affects the intention to use e-scooters (a) and to use the sharing service (b).*

As a result of the interviews and focus groups, it became clear that the anxiety construct, and exactly the components used to describe it, can be influenced by the users' internal uncertainty, which consists of uncertainty about driving any kind of vehicle, denial of micro transport (e-scooter), and lack of riding skills (see the hypothesis):

**Hypothesis 4 (H4):** *Personal internal uncertainty (IU) has a direct and positive impact on anxiety about use.*

One of the significant factors for the intention to ride e-scooters and use sharing services may be the preliminary experience of the consumer. Therefore, the corresponding hypotheses were formulated.

**Hypothesis 5 (H5a,b):** *The preliminary experience (Exp) in using e-scooters directly and positively influences the intention to use e-scooters (a) and to use the sharing service (b).*

For the development of micro-mobility in the city, it is necessary to know what can prevent it. One of the significant barriers may be road conditions, such as road quality, infrastructure, etc. This fact explains the inclusion of the following hypotheses in the study:

**Hypothesis 6 (H6a,b):** *Infrastructure quality (Infr) is significant for the consumer and has a direct and positive impact on the intention to use e-scooters (a) and to use the sharing service (b).*

From the point of view of one of the modern concepts of consumer behavior “jobs to be done (JTBD)”, a product is “hired” to do a certain work. People “hire” a product or service to do the work, in order to satisfy the need for the product or service and to perform the work that the consumer needs. According to our assumption, the interest of residents in doing the “work” that an e-scooter can perform should positively influence the attitude towards sharing, as well as an intention to use e-scooter and to use sharing services. Therefore, the following hypotheses were set:

**Hypothesis 7 (H7a,b):** *The functions of e-scooters (JTBD), interesting for residents, directly and positively influence the intention to use e-scooters (a) and to use the sharing service (b).*

The JTBD construct in relation to e-scooters can be influenced by the opinion of consumers about the level of perceived safety of the e-scooter for all road users: the perceived safety. There is also a possibility that perceived safety may influence the intention to use e-scooters and to use sharing services. To test this assumption, a hypothesis was formulated:

**Hypothesis 8 (H8):** *The opinion of consumers about the high level of perceived safety (PSaf) of the e-scooter for all road users has a direct positive effect on the JTBD construct in relation to the e-scooter.*

The attitude of people towards the difficulty of training to ride and then using an e-scooter, i.e., effort expectancy, can affect many other components of the model. However, first of all, this should be expected regarding the intention to use an e-scooter, attitude towards sharing, and sharing constructs. The level of effort expectancy is estimated conversely, the less effort it takes to master and use e-scooter, the higher the effort expectancy is [34]. Therefore, in this connection, the corresponding hypotheses were formulated:

**Hypothesis 9 (H9a,b):** *Effort Expectancy (EE) directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).*

The design of an e-scooter has both advantages and disadvantages for the user. For the development of urban micro-mobility, the e-scooter must meet the needs of the user, in order to perform the expected JTBD, and the design should facilitate this and not make this job more difficult.

Therefore, a hypothesis, evaluating the design features of e-scooters that are the most important for consumers was included in the study:

**Hypothesis 10 (H10a,b):** *The design (Des) features of the scooter directly affect the intention to use e-scooters (a) and to use the sharing service (b).*

The authors included in the survey questions indicating a “new way of thinking”. Some scholars associate the development of micro-mobility with a more responsible attitude of people to the environmental issues and the formation of more favorable environment. This may be due to the desire of residents to participate in the preservation of the environment; for example, by reducing personal use of vehicles with an internal combustion engine, and reducing the traffic load in the city. In addition, the influence of the new way of thinking on the use of e-scooters, most likely, may depend on a person’s attitude to the role of the residents and e-scooters in solving such issues. As a result, the following hypotheses were set:

**Hypothesis 11 (H11a,b):** *The new way of thinking (NWT) directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).*

One of the components of UTAUT is social influence. It refers to personal estimates of the attitude of close and significant people, and society as a whole, to riding e-scooters



and using a sharing service [33]. Since, the use of the e-scooter is ambiguously perceived by society, we considered it to be very important to find out how much social influence can affect the intention to use e-scooters and to use the sharing service. The following hypotheses were put forward:

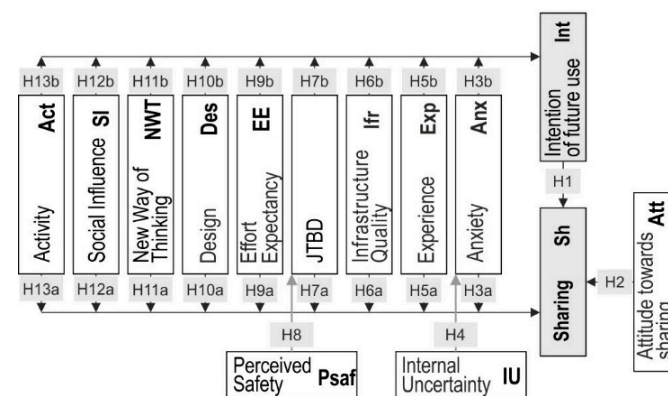
**Hypothesis 12 (H12a,b):** *The personal opinion on the positive attitude of society to the use of e-scooter (social influence, SI) directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).*

Scooters are often used for sports, maintaining physical activity, and health. In this regard, we tested the following hypotheses:

**Hypothesis 13 (H13a,b):** *Motivation to maintain physical activity and health (activity, Act.) directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).*

In addition, during the oral surveys, different attitudes towards the use of e-scooter were observed among men and women. Therefore, the influence of gender as a modifier on internal models was tested with PLS-SEM.

These hypotheses were set within the frameworks of the proposed research conceptual model (see Figure 1).



**Figure 1.** The proposed conceptual model of the research. (Source: figure was generated by the authors.).

### 3.3. Software and Statistical Analysis

Statistical data were processed using software the MS Excel 2010 and Statistica 8.0. StatSoft. Inc.

The calculations for the partial least square structural equation modeling (PLS-SEM) were done using the software 3.3.7. Smart PLS.

The threshold level of statistical significance  $\alpha$  was taken as the value of the criterion  $p < 0.05$ .

For  $p$ , the values of which in SmartPLS were 0.0000, we used the following method of presentation:  $p < 0.001$  [77].

The data in this research are presented in the form “mean  $\pm$  standard deviation”.

### 3.4. Estimation of Model in SmartPLS Software

The PLS-SEM analysis in SmartPLS was carried out in three stages:

(1) Outer model or construct validity was evaluated. The analysis comprised testing the reliability and validity of the model, including the investigation of indicators loadings for the theoretically determined constructs. In addition, the number of iterations required by SmartPLS® to complete the evaluation was determined.

(2) The inner model (structural model) evaluated the relationships between the constructs. This was done using coefficient of determination (R2), standardized path co-

efficients ( $\beta$ ), and their significance level ( $p$ ), as well as effect size ( $f^2$ ) and predictive relevance ( $Q^2$ ).

(3) A general assessment of the model (overall model assessment) was carried out, to check how well it corresponded to the data. In SmartPLS, this can be done using SRM, exact fit criteria  $d_{LS}$  and  $d_G$ , FI and RMS\_theta.

Table 2 reflects all the criteria used and their limit values in the PLS-SEM analysis at all stages.

**Table 2.** Recommended assessment of PLS-SEM.

Assessment	Criterion	Rules of Thumb/Desired Value
<b>Algorithm settings and software</b>		
Number of iterations	Stop criterion	Sum of the outer weights' changes between two iterations <10–5 [78] Maximum number of iterations: 300 [79]
<b>Outer model evaluation (construct validity)</b>		
Item reliability	Indicators loadings (IL)	>0.70 [80] >0.50 [81,82] >0.40 [83]
Convergent validity <sup>1</sup>	Composite reliability (CR) <sup>2</sup>	>0.80 [84] >0.70 (in exploratory research 0.60 to 0.70 is considered acceptable) [21,82,85,86]
	Average variance extracted (AVE)	>0.50 [87] AVE >0.5 and CR <0.6 [85]
Discriminant validity	Fornell and Larcker (F&L)	
	Divergent validity heterotrait:monotrait ratios (HTMT)	Values lower than 0.85 for conceptually distinct constructs and below 0.90 for conceptually similar constructs; confidence intervals should not include a value of 1 [67,88]
<b>Inner model evaluation (structural model)</b>		
Coefficient of determination	R <sup>2</sup>	Higher value is preferred: 0.67 substantial, 0.33 average, 0.19 weak [19,89]
Standardized path coefficients	Beta ( $\beta$ )	Values from –1 to +1. Assess significance and confidence intervals
Significance of the paths coefficients	$p$ -values	Significance value is based on the degrees of freedom $p < 0.05$ [82]
Effect size	$f^2$	0.02 weak, 0.15 moderate, 0.35 strong effects [89,90]
Predictive relevance	$Q^2$	>0.5 [19]
<b>Overall model assessment</b>		
Fit Measures	Standardized Root Mean Square Residual (SRMR)	<0.08; Confidence Intervals [88]
	Bentler and Bonett Index: normed fit index (NFI)	>0.09, the closer NFI to 1, the better the match [91,92]

<sup>1</sup> Convergent validity shows that the studied variables really reflect the latent constructs intended for measurement.

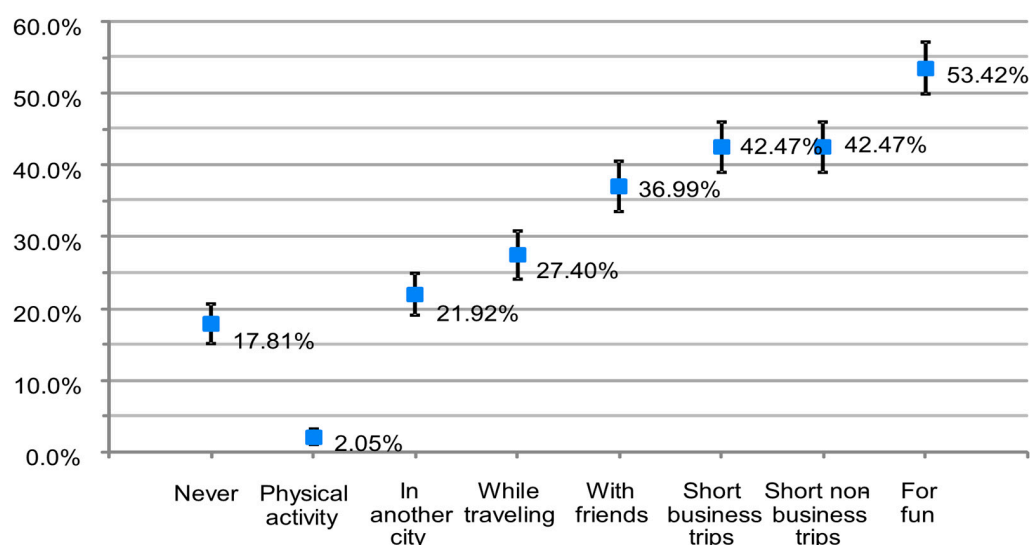
<sup>2</sup> Reliability of the design, a measure of the internal consistency of the scale elements. Source: generated by the authors.

## 4. Results

### 4.1. Preliminary Research

The interviews with e-scooter users and focus groups resulted in a comprehension of the main reasons for their use and non-use, as well as the possible JTBD of e-scooters

and barriers to their sharing. The details of the preliminary research are not presented in this article, since they were only important for the compilation of the survey questions and formed the basis for its development. For example, a list of purposes for using the e-scooter sharing service was compiled; despite the fact that the question was semi-closed, there were no additional answers from the respondents. Only 17.81% (n = 130, 95% CI 15.03–20.58%) of young residents of Riga would never take advantage of using an e-scooter sharing service. Considering only these respondents who do not have the intention to use e-scooter sharing services, only 76.92% (95% CI 73.87–79.98%) of them do not plan to use an e-scooter in the future. It should be noted that 50.68% of all respondents had experience in using e-scooters (n = 370, 95% CI 47.06–54.31%). We should emphasize, that there were no significant gender differences in the experience of using e-scooters in the study sample: 53.85% male and 47.06% female respondents had experience of riding e-scooters (see Figure 2 in the text and Table A1 in the Appendix A).



**Figure 2.** Frequency of respondents choosing different purposes for using e-scooter sharing services (data are presented as % ± 95% CI). (Source: generated by the authors).

Most often, an e-scooter sharing service is used for entertainment (53.42%, n = 390, 95% CI 49.81–57.04%), more rarely for various short trips (42.47%, n = 310, 95% CI 38.88–46.05%), while, 39.73% (n = 290, 95% CI 36.18–43.28%) of respondents generally used it when they go to another city and while traveling. E-scooters sharing services are largely not used for sports and maintaining physical activity (2.05%, n = 15, 95% CI 1.03–3.08%). The latter is most likely due to the fact that user’s own rather than shared e-scooters are used for such purposes. This is the reason why the Hypothesis 13 was not tested after the preliminary research.

The data used for constructing Figure 2 are presented in Table A1 in Appendix A.

According to the media, scientific literature, and our preliminary surveys, there is no unambiguous attitude to the use of e-scooters [37,43,59].

The attitude of society towards this issue can significantly influence the development of micro-mobility. The question is whether society is ready for legislative regulation. The survey showed that 67.12% (n = 490, 95% CI 63.72–70.53%) of young residents of Riga believe that the active use of e-scooters in the city needs legislative regulation. Moreover, the attitude to this issue among those who had experience in riding an e-scooter does not differ from all respondents, they were 67.57% (n = 250, 95% CI 64.17–70.96%).

The respondents who had experience in using e-scooters believed that their insufficient safety can serve as a barrier to the use of e-scooters (45.95%, n = 170, 95% CI 42.33–49.56%).

Thus, a paradoxical situation is observed. On the one hand, the vast majority of young residents who do not have experience in riding an e-scooter want to use an e-scooter

sharing service. On the other hand, many people consider this type of transport unsafe; the use of which needs legislative regulation. In many cities this type of micro-mobility is increasingly being developed, despite some rejection from society and the lack of proper regulation. The necessity to take into account the interests and fears of the young urban population (exemplified by Riga city residents) serves as an argument for the relevance and topicality of the presented research.

#### 4.2. Outer Model Evaluation—Construct Validity

The model in SmartPLS software was constructed based on the relations demonstrated by the set hypotheses. As a result of the implementation of PLS-SEM in SmartPLS 3.7, first of all, the indicators of latent variables with loadings  $>0.60$  were selected, since such a boundary value is permissible for exploratory research [82] (see Table 2). This boundary value was less than the recommended 0.70, but we settled on such a boundary value because this study is an exploratory one, and the important task was not to build a predictive model, but to identify the indicators that are significant for the studied constructs and would ultimately allow understanding the factors that can influence the development of e-scooter sharing services. This is important from the point of view of practical recommendations for business and municipal authorities related to micro-mobility and other stakeholders. In addition, according to the recommendation of [82,93], indicators with external loadings from 0.40 to 0.70 should be removed only if their removal leads to an increase in the overall reliability and AVE above the proposed threshold value. When analyzing the model, we took into account that low loadings can be the result of (1) a poorly formulated element, (2) an unsuitable element, or (3) an incorrect transfer of an element from one context to another [94]. The second reason was solved by removing the “unnecessary components”. However, solving the problem of poorly formed elements will be the task of future studies. In the future, it will be necessary to improve the indicators of such constructs as design, infrastructure quality, new way of thinking, internal uncertainty, and social influence.

It should be noted, that the authors developed two models. Model 1 was the actual model which we used for exploratory purposes and for preparing the recommendations for the stakeholders of e-scooter sharing services. The second model was constructed as a statistically ideal model from the point of view of the overall model assessment (standardized root mean square residual—SRMR, see Table 2), corresponding to all parameters of PLS SEM. Model 2 has significantly fewer indicators and was only constructed to check the ideal statistical parameters. All further results, recommendations, and discussion refer to Model 1 only. The details of Model 1 and Model 2 are shown in Table A2 in Appendix A.

Presenting Model 1, the authors determined the indicators with appropriate loadings for each construct.

1. Anxiety (Anx) includes: Lack of confidence on the road (indicator loading—IL = 0.762), Possibility of emergency situations (IL = 0.740), Poor knowledge of traffic rules (IL = 0.727);
2. Design (Des) comprises: Inability to transport things (IL = 0.874) and Fear of lack of charge (IL = 0.659);
3. Experience (Exp) has only one indicator: Experience in using an e-scooter;
4. Attitude towards sharing (Att) encompasses the indicators: It is always better to use sharing services (IL = 0.947); and It is more convenient to use sharing services (IL = 0.915);
5. Intention of future use (Int)→has only one indicator: Intention to use the e-scooter in the future (IL = 1.000);
6. Infrastructure Quality (Infr)→includes: Poor quality of road (IL = 0.864), Dirt on the roads (IL = 0.712), Poor infrastructure (availability of parking lots, availability of charging places, existence of special road lines for micro-mobility, etc.) (IL = 0.620);
7. Effort Expectancy (EE) encompasses: E-scooters are easy to use (IL = 0.999), It is easy to learn how to ride an e-scooter (0.889);

8. Social Influence (SI) includes: Positive assessment of the society (IL = 0.647); and Irritates city residents (IL = 0.912) (the scale data were inverted);
9. New Way of Thinking (NWT) is made up of: Specialists of the future should have a new mindset focused on lean manufacturing, resource conservation, environmental thinking, and a systematic approach (IL = 0.9400); A company benefits from the transition to the use of electric transport (IL = 0.633), Each member of society should contribute to reducing the transport load of the city (IL = 0.651);
10. JTBD comprises: Speed of movement (IL = 0.851); Route optimization (IL = 0.782); Replacement of public transport at certain distances (IL = 0.753); Taxi replacement at certain distances (0.731); and Car replacement at certain distances (IL = 0.610);
11. Perceived Safety (PSaf) includes: E-scooter is safe for pedestrians (IL = 0.927); E-scooter is safe for scooter drivers (IL = 0.920);
12. Sharing (Sh) is made up of one indicator: Using sharing service for any purpose;
13. Internal Uncertainty (IU) consists of: Uncertainty about driving any vehicles (IL = 0.918); and Negative attitude towards this type of transport (IL = 0.685).

The values of the criteria for outer model evaluation (construct validity), namely composite reliability (CR), average variance extracted (AVE), and predictive relevance with omission distance (Q2), were within the required boundaries (see Table 3), which are specified in Table 2. All constructs demonstrated high reliability values for internal consistency. The considered variables really reflected the latent constructs intended for measurement: composite reliability was >0.7 and the average variance extracted >0.50. It should be noted that for PLC-SM, it is preferable to use composite reliability rather than Cronbach’s alpha [95].

**Table 3.** Measurement values: composite reliability (CR), average variance extracted (AVE), predictive relevance with omission distance (Q2), standard deviation (STDEV), and coefficient of determination (R<sup>2</sup>) with confidence interval and *p* value (*p*).

Constructs	CR	AVE	Q2	R2			
				Value	STDEV	CI 95%	<i>p</i>
Anxiety	0.788	0.553	0.209	0.439	0.095	0.237–0.556	<0.001
Attitude towards sharing	0.929	0.867	0.192	0.249	0.097	0.072–0.358	0.004
Design	0.746	0.599					
Effort expectancy	0.916	0.845	0.153	0.123	0.064	0.042–0.238	0.023
Experience	1.000	1.000					
Infrastructure quality	0.778	0.544	0.120	0.164	0.086	0.010–0.278	0.030
Intention of future use	1.000	1.000	0.322	0.421	0.093	0.248–0.536	<0.001
Internal uncertainty	0.725	0.582					
JTBD	0.855	0.547	0.126	0.266	0.102	0.110–0.421	0.003
New way of thinking	0.793	0.569					
Social influence	0.764	0.625					
Perceived safety	0.921	0.853					
Sharing	1.000	1.000	0.628	0.703	0.071	0.54–0.781	<0.001

Source: generated by the authors.

The evaluation of discriminant validity is considered mandatory for outer model estimation, and it indicates the difference between the constructs within the model. Two common methods are used to evaluate the discriminatory validity in PLS SEM: the Fornell–Larcker criterion, and the Heterotrait–Monotrait ratio of correlations (HTMT).

The Fornell–Larcker criterion dominates for evaluating the discriminant validity in PLS-SEM. It should be noted that the Fornell–Larcker criterion is considered to be less powerful, error-prone, and ineffective under certain circumstances [78,96]. The Heterotrait–Monotrait ratio of correlations (HTMT) method is a stricter criterion [88]. Moreover, Hair et al. [78] recommended not relying on the Fornell–Larcker method, because of its exaggerations when detecting discriminant validity, but to use HTMT [67]. However, in

order to evaluate the discriminant validity, it is also suggested to take into account the model setting and the degree of the researcher's conservatism in evaluating the discriminant validity [97]. The obtained results fully met the Fornell–Larcker criterion: cross-loads showed that each indicator had the highest loads in the construct that it was originally supposed to measure (see Table A3 in Appendix A). Nevertheless, not all latent variables met the HTMT criterion (see Table A4 in Appendix A). A lack of discriminant validity was observed between anxiety and internal uncertainty, design and infrastructure quality, and internal uncertainty and new way of thinking and social influence. This situation might be due to the lack of accuracy in determining the components of these variables. We suggest that the reason for these constructs showing a high level of similarity should be considered in further studies.

However, for our exploratory research, the most important thing was to identify the indicators of latent variables, in order to consider the possibilities of their use in the real practice of smart city management and business development. Therefore, if the indicators showed good significance in the model, according to criteria other than HTMT, we considered it possible to focus on them when elaborating recommendations for the development of urban micro-mobility.

For a more complete exploration, we “cleaned” the constructs, so that the HTMT and the approximate fit indices SRMR (standardized root mean square residual) [98] discrimination indicators improved. After this procedure, when discriminating by HTMT, there remained one value  $>0.90$  at the intersection of the design and infrastructure constructor. HTMT evaluates the similarity between the constructs of the model. The design construct was determined by the importance for users of “The impossibility of transporting things on an e-scooter” and “Fear of lack of charge on an e-scooter”, while the infrastructure construct considers “Poor quality of roads” and “Dirt on the roads”.

The constructs obtained from these indicators might be similar digitally, but not in meaning, since they reflect completely different categories: the first is the structure of the scooter, and the second is the condition of the road. Multiple regression was used to analyze the similarity between these latent variables. There is a statistically significant relationship between the standardized latent variables design and infrastructure: Spearman rank order correlations  $0.45, p < 0.001$  and the adjusted coefficient of determination (adjusted R-squared), which evaluates the quality of the model fit, was only  $0.18 (p < 0.001)$ . This means that only 18% of the variance of one variable is explained by the variance of another, whereas when placing actually related indicators in different constructs (for example, in one “replacement of public transport” and “speed of movement”, and in the other “taxi replacement” and “route optimization”) the Spearman rank order correlation was  $0.71, p < 0.001$  and, accordingly, the adjusted coefficient of determination was  $0.49 (p < 0.001)$ .

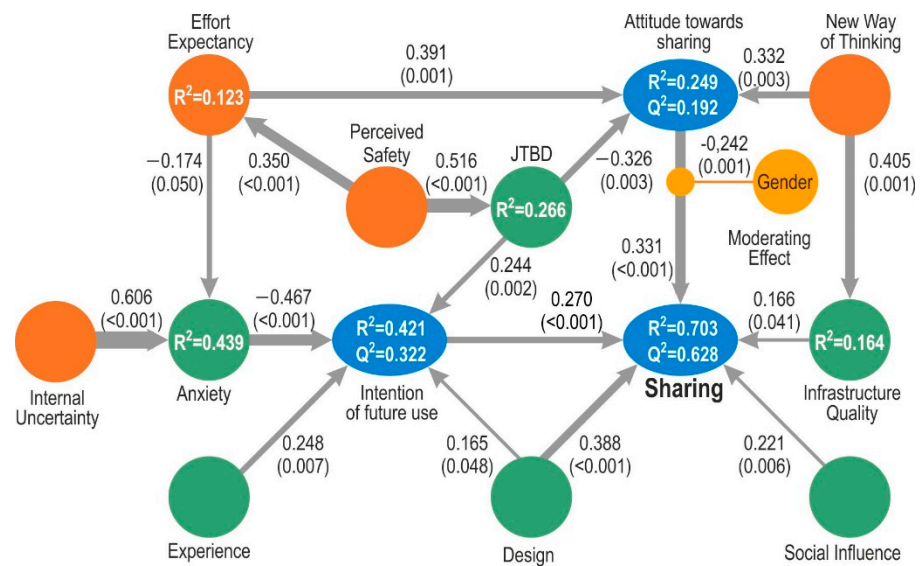
The question is whether it is possible, under these circumstances, to consider the similarity of the design and infrastructure constructs as valid and true, or whether it is explained by behavioral determinants that form a certain style of behavior and attitudes towards the various issues. Most likely, it is for this reason that in some cases latent variables may be similar, but at the same time they cannot replace each other, since they characterize different areas of interest and do not create a superabundance. It is also worth mentioning here that some authors reported that PLS-SEM does not cope well with the multicollinearity problem [21].

#### 4.3. Inner Model Evaluation (Structural Model)—Testing the Hypotheses

The inner model describes the relationships between constructs using coefficient of determination ( $R^2$ ), standardized path coefficients ( $\beta$ ), and their significance level ( $p$ ), as well as effect size ( $f^2$ ) and predictive relevance ( $Q^2$ ). The analysis stopped after three iterations, which is less than the permissible 10 iterations [67,79].

As has been mentioned, first, we investigated the model using the relationships specified in the framework of the model (see Figure 1). Then, in the course of improving the model and determining a more significant design for sharing, other relationships between

latent variables were considered. Therefore, effort expectation, JTBD, perceived safety, and new way of thinking found more optimal relations, which was not provided in the framework of the model (Figure 3).



**Figure 3.** Structural model of e-scooter sharing. (Source: generated by the authors based on PLS-SEM in SmartPLS) N.B.: The path coefficients are shown on the arrows and *p*-levels are in brackets. Source: generated by the authors.

In the present study, the  $R^2$  and  $Q^2$  values for the constructs “intention of future use” and “sharing”, as the target variables of the model, were of the greatest interest. The latent variables of the model explained about  $42.1 \pm 0.93\%$  of the differences in the intentions of Riga residents to use e-scooters for any purpose and  $70.3 \pm 0.071\%$  in the intentions to use the e-scooter sharing services. This is a fairly high level of  $R^2$ , which indicates that this study identified the main variables that can be used in the development of e-scooter sharing services in Riga and, most likely, in cities similar in size and infrastructure.

Only three of nine hypotheses about the direct connection of intention of future use with other variables were confirmed (see Table 4). At the same time, the greatest overall and negative effect on intention of future use was observed from anxiety ( $\beta: -0.467 \pm 0.092$ ,  $p < 0.001$ ), the value of which, in turn, significantly depended on the internal uncertainty ( $\beta: 0.606 \pm 0.090$ ,  $p < 0.001$ ) and to a small extent from the effort expectation ( $\beta: -0.174 \pm 0.103$ ,  $p = 0.017$ ). Moreover, JTBD ( $\beta: 0.244 \pm 0.086$ ,  $p = 0.002$ ), design ( $\beta: 0.165 \pm 0.098$ ,  $p = 0.047$ ), and experience ( $\beta: 0.248 \pm 0.098$ ,  $p = 0.006$ ) had insignificant direct positive effects on the intention of future use.

Five hypotheses of the 10 hypotheses about the direct effects of latent variables on sharing were confirmed (see Table 4). Individually, the variables demonstrated not very strong, but statistically significant, positive effects: intention of future use ( $\beta: 0.270 \pm 0.074$ ,  $p < 0.001$ ), design ( $\beta: 0.388 \pm 0.109$ ,  $p < 0.001$ ), attitude towards sharing ( $\beta: 0.331 \pm 0.071$ ,  $p < 0.001$ ), infrastructure quality ( $\beta: 0.166 \pm 0.090$ ,  $p = 0.032$ ), and social influence ( $\beta: 0.221 \pm 0.083$ ,  $p = 0.004$ ).

For the purpose of developing in the city the micro-mobility connected with e-scooters, it is important to understand all the factors that influence the intention to use e-scooters in the future and to use sharing services. Therefore, variables that have an indirect statistically significant relationship with the intention of future use and sharing should not be overlooked. Indirect general effects were insignificant and associated with the variables perceived safety ( $\beta: 0.154 \pm 0.054$ ,  $p = 0.005$ ) and internal uncertainty ( $\beta: -0.283 \pm 0.072$ ,  $p < 0.001$ ) (see Table A5 in the Appendix A).

**Table 4.** Results of testing the hypotheses.

Hypotheses	Result of Checking
<b>H1:</b> The intention to use the e-scooter in the future has a direct positive impact on the use of sharing for various purposes.	Confirmed
<b>H2:</b> A positive attitude towards e-scooter sharing has a direct positive impact on the use of sharing for various purposes.	Confirmed
<b>H3a,b:</b> Consumer's anxiety directly negatively affects the intention to use e-scooters (a) and to use the sharing service (b).	(a) Confirmed, (b) Partially confirmed (indirect effect)
<b>H4:</b> Personal internal uncertainty has a direct and positive impact on anxiety about its use.	Confirmed
<b>H5a,b:</b> The preliminary experience in using e-scooter directly and positively influences the intention to use e-scooters (a) and to use the sharing service (b).	(a) Confirmed, (b) Partially confirmed (indirect effect)
<b>H6a,b:</b> Infrastructure quality is significant for the consumer and has a direct and positive impact on the intention to use e-scooters (a) and to use the sharing service (b).	(a) Not Confirmed, (b) Confirmed
<b>H7a,b:</b> The functions of an e-scooter (JTBD), interesting for residents, directly positively influence the intention to use e-scooters (a) and to use the sharing service (b).	(a) Confirmed, (b) Not Confirmed
<b>H8:</b> The opinion of consumers about the high level of perceived safety of the e-scooter for all road users has a direct positive effect on the JTBD construct in relation to the e-scooter.	Confirmed
<b>H9a,b:</b> Effort expectancy directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).	(a) Not Confirmed, (b) Partially confirmed (indirect effect)
<b>H10a,b:</b> The design features of the scooter directly affect the intention to use e-scooters (a) and to use the sharing service (b).	(a) Confirmed, (b) Confirmed
<b>H11a,b:</b> The new way of thinking directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).	(a) Not Confirmed, (b) Partially confirmed (indirect effect)
<b>H12a,b:</b> The personal opinion on the positive attitude of society to the use of e-scooter directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).	(a) Not Confirmed, (b) Confirmed
<b>H13a,b:</b> Motivation to maintain physical activity and health directly positively affects the intention to use e-scooters (a) and to use the sharing service (b).	(a) Not Confirmed, (b) Not Confirmed

Source: generated by the authors.

Indirect relations help to understand the importance of taking into account the studied variables and their indicators in the development of e-scooter sharing services. For example, despite the strong effect of perceived safety with effort expectation and JTBD, the total indirect effects perceived safety on sharing turned out to be statistically insignificant (see Table A5 in Appendix A). At the same time, variables such as effort expectation, new way of thinking, experience, internal uncertainty, and anxiety had a weak, but statistically significant, effect on sharing, mediated by other variables (see Table A5 in the Appendix A).



All these variables, together, form a significant influence on sharing, which is expressed by the coefficient of determination  $R^2$  of 70.3%.

In the process of selecting the variables for constructing the model, we turned to the concept “jobs to be done” (JTBD). In accordance with this concept [99,100], the respondents in the course of oral surveying were asked what kind of “work” the e-scooter can perform for them and what kind of “work” they would like to receive from the e-scooter. As a result of the literature analysis, e.g., [37,43,53,59], etc., (see Table 1), and the authors’ research, such “works” as speed of movement, route optimization, and replacement of public transport at certain distances, etc., were included in the questionnaire (see Table A2 in the Appendix A). The indicators “ability to plan time better” and “saving money” had low indicator loads and were removed from the latent variable JTBD. This variable had no significant effect on sharing (see Table 5); however, it had a positive effect on the intention to use the e-scooter ( $\beta: 0.244 \pm 0.08, p = 0.002$ ), and a negative effect on attitude towards sharing ( $\beta: -0.326 \pm 0.118, p = 0.003$ ) (see Table 5).

**Table 5.** Direct effects: path coefficients ( $\beta$ ), standard deviation (STDEV), T Statistics (T-St),  $p$  Values, 5% and 95% confidence intervals (CI).

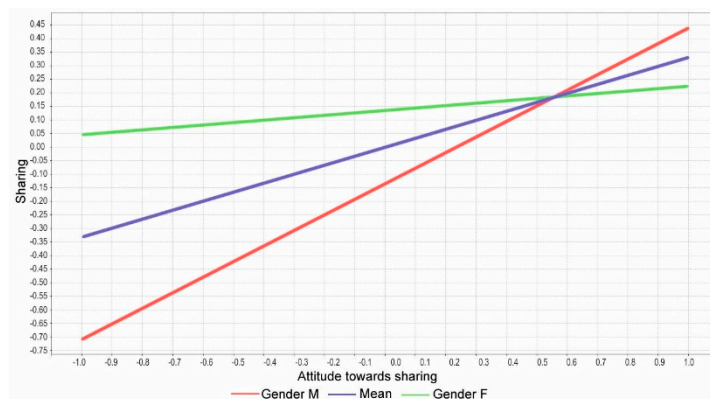
Variables	$\beta$	STDEV	T-St	$p$	5% CI	95% CI
Anx→Int	−0.467	0.08	5.864	<0.001	−0.593	−0.333
JTBD→Int	0.244	0.086	2.831	0.002	0.097	0.375
Des→Int	0.165	0.098	1.677	0.047	0.002	0.323
Exp→Int	0.248	0.098	2.533	0.006	0.074	0.405
Int→Sharing	0.270	0.074	3.625	<0.001	0.141	0.378
Des→Sharing	0.388	0.109	3.555	<0.001	0.191	0.561
Att→Sharing	0.331	0.071	4.687	<0.001	0.224	0.453
Infr→Sharing	0.166	0.090	1.852	0.032	0.025	0.328
SI→Sharing	0.221	0.083	2.656	0.004	0.083	0.352
EE→Att	0.391	0.129	3.022	0.001	0.159	0.564
JTBD→Att	−0.326	0.118	2.756	0.003	−0.519	−0.156
NWT→Att	0.332	0.126	2.633	0.004	0.13	0.535
I U→Anx	0.606	0.090	6.727	<0.001	0.452	0.749
EE→Anx	−0.174	0.103	1.689	0.046	−0.342	−0.017
PSaf→JTBD	0.516	0.093	5.551	<0.001	0.364	0.665
NWT→Infr	0.405	0.146	2.774	0.003	0.205	0.574
PSaf→EE	0.350	0.089	3.955	<0.001	0.189	0.477

Source: generated by the authors.

The assessment of the moderating effect of gender on all relationships revealed only one significant effect: a slight negative effect on the relationship attitude towards sharing and sharing ( $\beta: -0.242 \pm 0.074, p < 0.001$ ). The meaning of this influence can be understood from the simple slope analysis (see Figure 4). As follows from the angle of the slope of the straight curves “M” and “F” for male respondents, there was a high dependence between these variables, whereas for female respondents this dependence was practically absent. According to other studies, women are less interested in using e-scooter sharing services than men [39]. However, the other studies did not observe gender differences in this issue [101].

#### 4.4. Hypotheses Testing Results

After estimating the outer and inner models, some hypotheses were rejected and some of them were supported. The obtained results are presented in Table 4.



**Figure 4.** Simple slope analysis of moderating effect of variable “gender” on relation of “attitude towards sharing” and “sharing” constructs.

#### 4.5. Overall Model Assessment

A PLS SEM analysis cannot be considered complete without an overall model assessment. Unfortunately, this estimate turned out to be not very good; the result of standardized root mean squared residual (SRMR) was 0.133, while the required value is  $<0.080$ . However, this value is not so bad as to not take into account the results obtained during this exploration. Moreover, after radical “cleaning” of the variables from indicators with a load of  $<0.7$  (see Table A2 in Appendix A, Model 2), SRMR approached the recommended limit and became 0.086.

All these facts allow us to consider the task completed and the conducted exploration as quite successful, with some limitations and an understanding of further research directions. Therefore, in the discussion section we will discuss some opportunities for the development of e-scooter sharing services in the city.

## 5. Discussion

The contemporary urban environment faces new challenges and has to solve issues connected to the traffic, pollution, organization of human activities, and so on. Part of these challenges can be solved via smart city development.

One of the smart city components is smart people. Attitudes of city residents towards various issues are very important for smart city implementation at all levels. The behavior of the population is widely discussed in many research works, for example, Ref. [102] discuss the acceptance of web applications and readiness to use them for everyday operations in a smart city. This is substantial for another feature of the smart city: the development of the idea of exchanging the ownership concept for a sharing concept, which should contribute to better allocation of resources, a better ecological situation, and a more comfortable way of living for urban populations. The concept of sharing has pros and cons [9], but the discussion of advantages and disadvantages of sharing is beyond the framework of this article. The authors consider in this article sharing services as a part of the smart economy, which is a constituent part of the smart city and partially determined by smart people. Another activity discussed within the smart city concept is micro-mobility, which is suggested as a partial solution to the traffic problems in the urban environment. Therefore, the authors focused their research on these two elements of the Smart City and considered the factors impacting the development of micro-mobility (namely, standing e-scooters) and e-scooter sharing services in Riga, Latvia.

As the analysis shows, e-scooters are a very attractive mode of transport in urban environments, and their importance is expected to grow.

Taking into account the obtained results regarding the relationship of the sharing construct with other variables, it is possible to make assumptions about the changes, which might affect the development of e-scooter sharing, the content of these changes, and how they can be adopted in society.

Not only the sellers, distributors, and manufacturers of e-scooter are the stakeholders of the development of micro-mobility in general, and e-scooters in particular, but also municipal authorities; micro-mobility can be developed due to sharing services, or due to various forms of ownership. Municipal authorities may be especially interested in improving legislation, taking into account the interests of all parties: residents, car owners, and e-scooters riders. They can create an infrastructure favorable for the traffic of all involved parties (pedestrians, car-drivers, e-scooter-riders, bike-riders, etc.); authorities can contribute to the improvement of the environmental situation and to the advancement of a smart city, due to the development of micro-mobility. Moreover, the concept of the smart city presupposes that the active and smart participation of local authorities can greatly contribute to its development.

One of the difficult issues in the development of urban micro-mobility, and e-scooters in particular, is the creation of safe conditions for the use of such transport [53]. A safe living environment is one of the most important tasks within a smart city. The inability to solve safety problems with e-scooters leads to strict regulation of their use [103,104]. For example, in Singapore and in France [105], it is forbidden to ride an e-scooter on the sidewalks, in the Netherlands there are many restrictions on riding e-scooters [106], in London it is permitted to use privately owned e-scooters only on private property, and not on public roads, bike paths, or sidewalks [107]. In many countries there are speed limits for e-scooters, tests conducted on the various forms of using e-scooters, and the development of corresponding laws and regulations [108,109]. The effectiveness of the introduction of laws depends on the attitude of the population towards them; on how much the laws are demanded by and approved by the society. According to our research, the young residents of Riga agree that the active use of e-scooters in the city needs legislative regulation and that it is necessary to improve safety, the absence of which can serve as a barrier to the use of e-scooters.

The use of e-scooters, as well as other vehicles, may be hindered by a sense of anxiety. Therefore, special attention should be focused on this negative effect of anxiety, which in this study was determined by such indicators as lack of confidence on the road, the possibility of accidents, and poor knowledge of traffic rules. Fear caused by these factors can serve as a serious barrier to the development of micro-mobility. On the one hand, we can say that a person should solve such problems for himself. However, on the other hand, solving such problems with the help of the municipality and businesses interested in developing the use of ES, can contribute not only to the activation of micro-transport traffic in the city, but also become a strong marketing factor. It is possible to reduce uncertainty and the fear of self-use of vehicles only with the help of appropriate training programs. Training, offered in various offline and online forms, will involve consumers in the process of developing micro-mobility, increasing the joint consumer value in relation to micro-transport. The importance of improving the knowledge and experience of riding e-scooters for the development of sharing services is confirmed by the fact that the experience variable has a positive effect both on the intention to use the e-scooter for various purposes and on their sharing. More frequent practice reduces feelings of anxiety about the use of e-scooters [37]. In addition, there is an opinion that sufficient safety propaganda on social networks can contribute to the decrease of unsafe driving practices without protective equipment [57]. It should be borne in mind that female riders might need to practice riding more than men; it could help them to cope with feelings of anxiety due to a feeling of disequilibrium or anxiety about falling [37]. In general, the components of a smart city (living and people) suggest attention towards the creation of conditions for self-development of the people for convenient and safe living, and these initiatives will contribute to the development of the smart city.

One of the possible problems of the active use of e-scooters, according to the interviewed young people, is the design features of the e-scooter, which does not allow carrying the necessary things and feeling safe about the battery charge. The same problem has been discussed in the same context in other studies [53,59]. The first can be solved by proposals for legalized tuning or the proposal of new e-scooter designs. The solution to the

second issue is most likely impossible without the municipality; that is, the widespread development of places for fast charging of batteries (not only at gas stations, but also, for example, at points of sharing and in catering places). This is also part of the infrastructure of a smart city, and its development will advance the development of the smart city.

To build an exploratory model, we used the theory of jobs to be done (JTBD), which represents the progress of scientific research dating back to the 1950s with the development of the theory of expected value in cognitive psychology [106], which is unfairly ignored by many researchers. According to the JTBD concept, goods and services should be considered in terms of the work that the client requires and that can be implemented with the help of these goods and services [110–113]. If the product does a good job, then there is a high probability that it will be hired in future. If a product does a “trashy” job, it is “fired” and replaced with an alternative one [113]. The customers do not just buy goods or services, they involve them in their lives, in order to make “personal progress” [114]. That is why the consideration of e-scooter sharing, from the point of view of JTBD seems very promising. After all, an e-scooter is not just a means of transportation, an e-scooter participates in the formation of a certain lifestyle, based not only on maintaining physical health, but also on a more environmentally friendly new way of thinking. The fact is supported by the obtained study results: the positive effect of the new way of thinking on e-scooter sharing was revealed. In addition, a positive effect of the JTBD variable on the intentions to use the e-scooter and a negative effect on attitude towards sharing was shown. The latter is most likely due to the fact that respondents with an expressed desire to receive these “works” (functions) from an e-scooter do not believe that it is always *better* to use sharing services for e-scooter, but it is *more convenient* to use sharing services. Apparently, the owning of an e-scooter is preferable to using the sharing services.

The fact that the e-scooter can do the required “work” well and that its functions are needed by consumers is confirmed by the fact that the e-scooter is considered an alternative or replacement for public transport, taxis, and, in some cases, a personal car, not only in our study, but also as proven by many prominent scholars [37,39,40,44,53]. Understanding the functions that e-scooter can perform for a city resident serves as a good basis for the development of this type of micro-mobility, both on the part of the municipality and on the part of businesses. It is the demanded functions of e-scooters that should underlie the formation of a marketing strategy and management of the development of e-scooter sharing services, and which fully coincide with the strategies of smart city development.

It should also be noted that e-scooters, despite all the contradictions of their use so far, can contribute substantially to the development of a smart city, due to improvement of many factors.

Almost all researchers mentioned the great value of micro-mobility for ecology. This transportation mode reduces the number of cars on the roads, especially for short-distance trips [1–3], and, according to European Environment Agency [115], traditional vehicle transportation produces a significant part of emissions in Europe. Therefore, low-carbon and sustainable micro-mobility improves the ecological situation [116]. It is very flexible and cost-efficient [30]. In rush hours, when the cities suffer with high congestion, micro-mobility allows reducing the time of travel [4,54]. Micro-mobility creates opportunities for the development of sustainable business within the city [117]; therefore, micro-mobility contributes to the smart city as a sustainable city.

Great importance is given to the social component of micro-mobility. The authors consider that the rates of adoption of micro-mobility [118,119] and the convenience for users have resulted in “unique affordances in use” and very quick integration of this transportation mode into the urban environment [8].

Nevertheless, micro-mobility, and especially standing e-scooters, create divisions among specialists, who consider them to be not so ecological as they seem, since micro-mobility mostly replaces, not car driving, but walking [119]. However, young people, according to the results of our research, consider riding an e-scooter as an alternative not for walking, but for using other mode of transportation (public transport, taxi, personal

cars). The behavior of young people regarding this issue is an interesting subject for further research and can become the objective of the next study of the authors.

The increased road risks for citizens are also at the center of attention of scholars [8,116,120–123], as was discussed above.

Another possible problem appears due to the fact that the businesses providing the micro-mobility services use applications, and create large and well-functioning databases. These databases improve the work with statistics and help the specialists [52,124]. Nevertheless, there appears the problem of the unethical uses of information [125], manipulating the data [126,127], and using them for monetization purposes [128].

Considering the negative effect of micro-mobility on some aspects of urban life, it is necessary to pay great attention to the regulation of micro-mobility, and there is research devoted to this issue [125,129].

As a result, we can conclude that micro-mobility facilitates meeting the requirements of the smart city: it decreases carbon footprints, solves some problems of city transport, changes the way of thinking of the population, makes the urban living environment more comfortable for citizens, creates new possibilities for businesses, is oriented toward smart allocation of resources, and, therefore, solves some local issues, faced by municipal authorities.

### 5.1. Research Limitations

The study was conducted on data selected within only one city, Riga. We assume that the residents of other cities, similar to Riga in size, cultural peculiarities, and habits will have similar influencing factors regarding the micro-mobility sharing services. However, this can be considered as a limitation of this research.

This study brings society closer to understanding the issues of the development of e-scooter sharing, but leaves many questions open. In particular, the role of such important variables as the new way of thinking, perceived safety, personal internal uncertainty, and social influence in the development of e-scooter sharing has only been indicated, but not fully revealed and described.

Another restriction is connected with the set of variables chosen for determining the model construct. The authors tried to consider all the possible indicators; nevertheless, it is possible to extend the range of used indicators, to use other factors, or implement another method of analyzing the data.

In addition, sampling studies are accompanied by survey errors; in particular, coverage errors and sampling error. A discrepancy between the sample and the general population is more or less inevitable. It should always be borne in mind that, if a large-scale randomized study has not been conducted, the results of a single sample study cannot be considered to be representative. In such cases, representative results can be obtained with multiple sample studies conducted by different authors.

It should also be noted that, in this study, the interpretation of the model was restricted by age limits, since only the residents of the age group of 18–35 participated in the survey. Other age groups also use this type of transport. Therefore, for a more adequate forecast that would be useful to the municipality and business, it is necessary to take into account the data of other age groups of residents, at least up to 60 years old.

In addition, the questionnaire was distributed electronically among the students and the graduates of the universities and colleges in Riga, as well as among young entrepreneurs and employees of several companies. There is no doubt that the respondents surveyed did not include all social groups of the residents of Riga. In addition, the survey did not take into account the quotas of each of the social groups in the structure of the population of Riga.

It is likely that the relationship between motivation to maintain physical activity and health and e-scooter sharing was not detected due to coverage errors.

However, all this does not mean that this sample study conducted with the help of a survey has no theoretical and practical significance. This means that, when interpreting

and using the results, this sampling error must be taken into account. This research is exploratory and was conducted in order to answer the fundamental questions that are important for assessing the conditions for the development of scooter rental in a city such as Riga. And in this regard, the results presented are suitable for both theoretical research and practical use.

### 5.2. Further Research Directions

It would be interesting to study why the young people move from walking or public transport to the use of e-scooter sharing, but not from active use of private cars. This may be interesting as a phenomenon, determining the behavior of young people in either CEE countries, or in all European countries.

We could also study the development of sharing services for other means of transportation in smart cities.

This study can serve as a basis for further large-scale studies with a larger number of respondents, to clarify the significant constructs and their indicators.

## 6. Conclusions

The concept of a Smart City presupposes an increased attention on creating a safe and convenient urban environment for city residents. Ecology, traffic in the streets, convenience of getting from one place to another; these are the problems that a Smart City should solve, and one of the solutions is the development of micro-mobility and sharing services. The present study was aimed at investigating the factors influencing the development of e-scooter sharing in Riga (Latvia).

The study was carried out using PLS-SEM in SmartPLS 3.7 software.

The target audience of the study was young residents of Riga (age 18–35), since they are thought to be the main users of this type of transport. The main purposes for using e-scooter sharing services are entertainment, short trips around the city for business, and other purposes, such as spending time with friends; they are also used when people come to other cities and during a trip to explore the city, for excursions, and for other purposes.

The authors used the constructs that were previously described in the literature and also new ones, not investigated in a similar context, as latent variables for PLS-SEM analysis. These comprised attitude towards sharing, anxiety, internal uncertainty, JTBD, and new way of thinking. All of them had a direct or indirect effect on the intention of future use and/or sharing variables. The indicators for the variables were determined on the basis of a literature review and surveying respondents, and then they were checked for loadings, convergent validity (CR, AVE), and discriminant validity (Fornell–Larcker Criteria and HTMT).

Within the constructed model, the latent variables explained about  $42.1 \pm 0.93\%$  of the differences in the intentions of Riga residents to ride e-scooters, and  $70.3 \pm 0.071\%$  of their intentions to use sharing services. This research identified the main variables determining the attitude of consumers towards using e-scooter sharing services. These data could be used for the development of e-scooter sharing services in Riga and, most likely, in other cities similar to Riga in size and infrastructure.

For the first time in such a study, the concept JTBD (jobs to be done) was used to determine the types of “work” that the consumer needs and which e-scooters can perform. The results showed that e-scooters are considered by young people as a replacement for public transport, taxis, and private cars, and the choice of this method of transportation is explained by faster movement in traffic jams and the possibility of optimizing the route.

The following barriers and factors can reduce the usage of e-scooter sharing services: perceived safety of using e-scooters, anxiety due to possible emergencies and poor knowledge of traffic rules, and also internal uncertainty associated with the uncertainty of driving any vehicles and a negative attitude to scooters as a transportation means. Municipalities and businesses interested in the development of e-scooter sharing services are able to reduce these unfavorable factors with training programs, including gaming and engaging methods.

Another important factor is that the municipality is the only structure able to solve the infrastructure problems, which can serve as a significant obstacle to the development of micro-mobility, in general, and e-scooter sharing services, in particular.

The development of e-scooter sharing is substantially affected by the positive attitude of society towards it, and on the other hand, the irritation of citizens associated with this mode of transportation. The only solution for neutralizing this situation is legislative regulation and monitoring of the implementation of these laws by e-scooter riders.

The study revealed the importance of a new way of thinking for the development of e-scooter sharing, including the ecological consciousness of young residents of Riga, understanding the problems of traffic load in the city, and positive attitudes towards micro-mobility as an alternative way of transportation, since it is a more suitable mode for the urban environment.

Thus, the conducted research brings us closer to a better understanding of the important factors influencing the development of urban micro-mobility and specifies the factors that are important for the development of this type of mobility. The residents, municipality and businesses are stakeholders of this process. The results can serve as a basis for the development of initiatives aimed at mitigating the negative effects of riding an e-scooter within the city and for informing the population about ways of creating a safe and comfortable urban environment.

The factors specified within this research can help e-scooter riders, pedestrians, and other participants of traffic to create a safe environment for using micro-mobility and preserving the environment.

The development of micro-mobility (including e-scooters) and the popularization of sharing services can significantly contribute to advancing Riga (and other cities) as a smart city.

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## Appendix A

**Table A1.** Frequency of respondents choosing different goals for using e-scooter sharing service (CI-confidence interval).

The Purpose of Using Sharing Service	n	% Yes	5% CI	95% CI
Never	130	17.81	15.03	20.58
For maintaining physical activity and/or sports	15	2.05	1.03	3.08
For entertainment	390	53.42	49.81	57.04
For short trips around the city for business purposes	310	42.47	38.88	46.05
Short movements for any purpose other than business	310	42.47	38.88	46.05
In another city	160	21.92	18.92	24.92
During a trip to explore the city, for excursions and for other purposes	200	27.40	24.16	30.63
To spend time with friends	270	36.99	33.48	40.49

Source: generated by the authors.

**Table A2.** Constructs of the model; their included and excluded indicators and their loading (IL).

Constructs and Their Indicators	IL	Model1	Model2
<b>Anxiety (Anx)</b>			
• Lack of confidence on the road	0.762		
• Possibility of emergency situations	0.740		
• Poor knowledge of traffic rules	0.727		excluded
• Difficult road situation	0.635	excluded	excluded
• The possibility of getting into an accident or other dangerous road situation	0.518	excluded	excluded
• Insufficient safety of riding e-scooter	0.470	excluded	excluded
<b>Design (Des)</b>			
• Inability to transport things	0.874		
• Fear of lack of charge	0.659		
• Unreliability of the design	0.296	excluded	excluded
• Inconvenience of movement in standing position	0.052	excluded	excluded
<b>Experience (Exp)</b>			
• Experience in using an e-scooter	1.000		
<b>Attitude towards sharing (Att)</b>			
• It is always better to use sharing services	0.947		
• It is more convenient to use sharing services	0.915		
<b>Intention of future use (Int)</b>			
• Intention to use the e-scooter in the future	1.000		
<b>Infrastructure Quality (Infr)</b>			
• Poor quality of road	0.864		
• Dirt on the roads	0.712		
• Poor infrastructure,	0.620		excluded
• Inconvenience or insufficiency of parking	0.340	excluded	excluded
<b>Effort Expectancy (EE)</b>			
• E-scooters are easy to use	0.999		
• It's easy to learn how to ride an e-scooter	0.889		excluded
<b>Social Influence (SI)</b>			
• Positive assessment of the society	0.647		
• Irritates city residents (invert) <sup>1</sup>	0.912		



**Table A2.** *Cont.*

Constructs and Their Indicators	IL	Model1	Model2
<b>New Way of Thinking (NWT)</b>			
• Specialists of the future should have a new mindset focused on lean manufacturing, resource conservation, environmental thinking and a systematic approach	0.940		
• The company benefits from the transition to the use of electric transport	0.633		excluded
• Each member of society should contribute to reducing the transport load of the city	0.651		excluded
• Every resident of the city should contribute to reducing environmental pollution (for example, using more environmentally friendly transport)	0.427	excluded	excluded
<b>JTBD</b>			
• Speed of movement	0.851		
• Route optimization	0.782		
• Replacement of public transport at certain distances	0.753		
• Taxi replacement at certain distances	0.731		excluded
• Car replacement at certain distances	0.610		excluded
• Ability to plan time better	0.217	excluded	excluded
• Saving money	0.178	excluded	excluded
<b>Perceived Safety (PSaf)</b>			
• E-scooter is safe for pedestrians	0.927		
• E-scooter is safe for scooter drivers	0.920		
<b>Sharing (Sh)</b>			
• Using sharing service for any purpose	1.000		
• Internal Uncertainty (IU)			
• Uncertainty about driving any vehicles	0.918		
• Negative attitude towards this type of transport	0.685		excluded
• Lack of skills	0.357	excluded	excluded

Source: generated by the authors. N.B. The minimum allowable level for a preliminary (exploratory) study for indicator reliability is 0.4, the preferred value is 0.70 and higher [76]. <sup>1</sup> For use in the model, the scale data were inverted.

**Table A3.** Discriminant validity, Fornell–Larcker criteria.

	Anx	AttSh	Des	EE	Exp	Infr	Int	IU	JTBD	NWT	SI	PSaf
<b>Anx</b>	0.744											
<b>AttSh</b>	−0.225	0.931										
<b>Des</b>	−0.028	−0.094	0.774									
<b>EE</b>	−0.295	0.364	−0.396	0.919								
<b>Exp</b>	−0.056	0.026	0.171	−0.127	1.000							
<b>Infr</b>	−0.127	0.099	0.507	−0.083	0.207	0.738						
<b>Int</b>	−0.509	0.022	0.234	0.057	0.296	0.247	1.000					
<b>IU</b>	0.640	−0.316	−0.153	−0.201	−0.119	−0.179	−0.442	0.763				
<b>JTBD</b>	−0.098	−0.033	0.060	0.360	−0.026	0.193	0.293	0.066	0.740			
<b>NWT</b>	−0.209	0.290	0.245	0.270	−0.041	0.405	0.198	−0.265	0.456	0.754		
<b>SI</b>	−0.296	0.32	−0.263	0.386	−0.004	0.045	0.057	−0.333	0.028	0.336	0.791	
<b>PSaf</b>	−0.134	−0.059	−0.222	0.350	−0.226	−0.018	0.163	−0.036	0.516	0.304	0.443	0.924
<b>Sh</b>	−0.350	0.424	0.489	0.126	0.185	0.497	0.402	−0.322	0.159	0.472	0.271	−0.013

Source: generated by the authors.

**Table A4.** Discriminant validity: Divergent validity Heterotrait–Monotrait ratios (HTMT).

	Anx	AttSh	Des	EE	Exp	Infr	Int	IU	JTBD	NWT	SI	PSaf
<b>Anx</b>												
<b>AttSh</b>	0.302											
<b>Des</b>	0.507	0.285										
<b>EE</b>	0.396	0.417	0.859									
<b>Exp</b>	0.096	0.029	0.251	0.146								
<b>Infr</b>	0.401	0.184	1.073 *	0.132	0.269							
<b>Int</b>	0.627	0.022	0.411	0.141	0.296	0.293						
<b>IU</b>	1.317 *	0.679	0.535	0.412	0.204	0.498	0.796					
<b>JTBD</b>	0.385	0.191	0.390	0.441	0.167	0.363	0.292	0.675				
<b>NWT</b>	0.520	0.311	0.529	0.304	0.068	0.656	0.241	0.961 *	0.735			
<b>SI</b>	0.499	0.530	0.732	0.658	0.279	0.374	0.133	0.938 *	0.498	0.254		
<b>PSaf</b>	0.223	0.068	0.391	0.413	0.250	0.190	0.180	0.344	0.617	0.410	0.812	
<b>Sh</b>	0.455	0.453	0.790	0.124	0.185	0.594	0.402	0.685	0.177	0.473	0.387	0.078

Source: generated by the authors. N.B.: \* The discriminant validity is established between two reflective constructions if the HTMT value is below 0.90 [71].

**Table A5.** Total and specific indirect effects: path coefficients ( $\beta$ ), standard deviation (STDEV), T statistics (T-St),  $p$  Values, 5% confidence interval CI, and 95% confidence interval CI.

Variables	$\beta$	STDEV	T-St	$p$ Values	5% CI	95% CI
PSaf→EE→Anx→Int→Sharing	0.008	0.007	1.096	0.137	0.000	0.021
PSaf→EE→Att→Sharing	0.045	0.025	1.818	0.035	0.012	0.090
PSaf→JTBD→Att→Sharing	-0.056	0.028	1.973	0.025	-0.113	-0.021
PSaf→JTBD→Int→Sharing	0.034	0.018	1.862	0.032	0.009	0.067
PSaf→Sharing	0.031	0.040	0.789	0.215	-0.031	0.097
JTBD→Int→Sharing	0.066	0.033	2.003	0.023	0.020	0.118
JTBD→Att→Sharing	-0.108	0.046	2.340	0.010	-0.197	-0.049
JTBD→Sharing	-0.042	0.056	0.750	0.227	-0.140	0.049
NWT→Att→Sharing	0.110	0.046	2.396	0.009	0.045	0.199
NWT→Infr→Sharing	0.067	0.047	1.440	0.075	0.001	0.149
NWT→Sharing	0.178	0.060	2.938	0.002	0.088	0.286
EE→Att→Sharing	0.130	0.054	2.383	0.009	0.050	0.215
EE→Anx→Int→Sharing	0.022	0.018	1.246	0.107	0.002	0.058
EE→Sharing	0.151	0.060	2.540	0.006	0.063	0.247
Des→Int→Sharing	0.044	0.029	1.553	0.061	-0.001	0.090
Des→Sharing	0.423	0.116	3.722	<0.001	0.230	0.626
Exp→Int→Sharing	0.067	0.035	1.917	0.028	0.016	0.130
IU→Anx→Int→Sharing	-0.076	0.027	2.857	0.002	-0.123	-0.035
Anx→Int→Sharing	-0.126	0.040	3.136	0.001	-0.195	-0.064
PSaf→EE→Anx→Int	0.028	0.021	1.351	0.089	0.002	0.064
PSaf→JTBD→Int	0.126	0.051	2.455	0.007	0.046	0.211
PSaf→Int	0.154	0.059	2.624	0.005	0.069	0.249
IU→Anx→Int	-0.283	0.072	3.902	0.000	-0.405	-0.157
EE→Anx→Int	0.081	0.055	1.479	0.070	0.007	0.185
PSaf→EE→Att	0.137	0.064	2.122	0.017	0.046	0.245
PSaf→JTBD→Att	-0.168	0.073	2.309	0.011	-0.305	-0.071
PSaf→Att	-0.031	0.088	0.350	0.363	-0.188	0.099
PSaf→EE→Anx	-0.061	0.041	1.495	0.068	-0.132	-0.006

Source: generated by the authors.

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