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FACTORS AFFECTING THE GROWTH OF DEMAND ON CARSHARING SERVICES WITHIN SMART CITY

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The carsharing services have become the necessary component of the life of smart and sustainable city. They meet the numerous requirements put forward by these cities concepts and make life in urban environment cleaner, more comfortable and convenient and better organized. The goal of this research is to determine the factors facilitating the demand for the carsharing services, and on the basis of this analysis to consider the costs structure of these companies. The results are obtained via PLS-SEM analyses implementation in SmartPLS-3.3.7 software. The analysis revealed that such factors as Convenience, Additional Values and Economic (saving factors) have positive impact on growth of demand for carsharing services while New Way of Thinking is insignificant. However, the developed Costs function demonstrate that companies assume the costs of promoting "green" effect of carsharing as important ones. If they reduce these types of costs, it will have positive impact on their efficiency without decrease of demand.

Keywords: smart city, carsharing services, sharing economy, PLS-SEM analysis, cost function

1. Introduction

The ideas of smart and sustainable development have touched upon all the spheres of urban life. It is reflected in new way of thinking, in new concepts entered the human life, in new phenomena appeared and became important for people. The contemporary life has changed the attitudes towards the institution of property and to positions for which people are ready or vice versa are not ready to spend money. People have new concerns about the convenience and values, proper lifestyle and behaviour. And one of the most important changes in the change in attitudes toward environment.

Sharing economy is assumed to be the important part of smart economy and, correspondently, of smart city. Nevertheless, it is also the constituent part of sustainability. Therefore, in case of considering sharing economy and its parts we consider that smart city is sustainable city, and they solve the common tasks and issues. Car sharing services solve multi-tasks for both concepts: smart and sustainable city. They exchange private transport in many cases, and reduce the pollution problems; they introduce more electric cars in the streets of the cities; they make traffic in the urban areas less intensive; they allow parking without evident problems in the city; they allow use the personal income in more efficient way, and so on. However, carsharing services are produced by businesses, and businesses are interested in developing these services.

The goal of this research is to determine the factors facilitating the demand for the carsharing services, and on the basis of this analysis to consider the costs structure of these companies.

The PLS-SEM analysis is conducted in SmartPLS-3.7 software; the data are received from semi-structured interviews with the carsharing businesses owners and survey of urban population.

The research has the practical value for many groups of stakeholders in the urban area.

There are some research limitations:

(1) The study was conducted only in two cities in Latvia, since the carsharing companies operate in Latvia in these cities only.

(2) The survey was conducted in the electronic form, and only people using the internet and social networks actively could participate in this survey.

(3) The indicators for forming the constructs were selected based on the preliminary semi structured interviews with the carsharing companies' owners; however, the set of indicators can be changed after more precise study.

The study has the following structure: Introduction, Literature Review, Methods, results and conclusion.

Literature Review section considers the scientific articles referring to smart and sustainable cities and the new paradigm of mobility.

Section Methods describes data collection procedure, model, PLS-SEM analysis and the procedure of analysis.

Section Results demonstrates the measurements of outer and inner model and hypotheses testing.

Conclusions summarise the findings of the article.

2. Literature Review

The concept of sustainability is widely used nowadays, it assumes that the contemporary generation of people should use the resources in the way that they cover all the needs nowadays without creating the negative effect on future generations (United Nations General Assembly, 1987). This way of development puts forward the specific requirements to the urban environments. One of the opportunities to meet these requirements is to develop the smart and sustainable city concept. There is no unified definition of sustainable city (Tang *et al*., 2016; Bednarska-Olejniczak *et al*., 2019), and the scholars emphasize various areas of the smart and sustainable city, having especially significant importance. the concept of smart is well developed, and related to the sustainability, it creates the sustainable standards for people who live and work in such environment (Kirimtat *et al*., 2020; Ismagilova *et al*., 2019). These standards result in new relationships between all economy participants (Kim *et al*., 2016).

Sharing economy is a wonderful example of such relationships, presupposing possibility to use resources without ownership in various integrated fields (Popova and Popovs, 2022). Substantial part of sharing economy is based on employment of digital platforms (Hamari *et al*., 2015; Schor *et al*., 2014). The digital platforms join the owner of "idle capacity", or under-utilized physical asset (Frenken and Schor, 2017) and people who are ready to use this capacity at the moment. These platforms put forward the requirements for the certain level of innovative development, which in turn will create the benefits for social welfare (University of Alicante, 2015).

Another effect of spread of ideas of sustainability including sharing economy is changed way of thinking of people. People also change in smart sustainable city, and active use of sharing economy is not occasional; it is the time when we start speaking about new way of thinking adopted by contemporary generation. Here it is possible to speak about new attitudes and approaches to the processes taking place in urban life, people use not only knowledge and competences, but also experience, opinion, new green ideas, and this new way of thinking finds its application in the solving the challenges of contemporary city (Lytras and Visvizi, 1998; Lytras, 2021; Visvizi, 2017). Moreover, new values appear, and they become common for various fields of life (Lim, 2020).

Sharing economy contributes to efficient allocation of resources (Popova, 2021; Hossain, 2020; Popova and Zagulova, 2022). It is beneficial for environment. And the carsharing services contribute to the environment preservation at full scope. There is no unified definition for this type of product; however, Government of Canada (2021) defines these services as "a car rental service that allows people to use vehicles for short periods of time, often by the hour". In other words, the car sharing services are the short-term rent of the car from a company or private person using special platform or application, and this business can be presented via different business models (Deloitte Monitor, 2017).

In general, mobility has greatly change, and today the new paradigm of mobility sets the new approaches to urban life, to movements and to transportation, considering them not only from technical point of view, but also from the social one (Popova and Zagulova, 2022b). Carsharing is one of the solutions for modern smart city. It can contribute to the development of more responsible behaviour of people, which is great social effect, it reduces traffic load in the city, decreases the use of individual vehicles, allows people drive the electric cars substituting the cars with an internal combustion engine (Popova and Zagulova, 2022b). Carsharing decreases the need in parking places in the city, since according to Louvet (2017), one car belonging to the company producing the carsharing services, can replace five personal vehicles. In total, some scholars expect that the overall amount of using vehicles will decrease, because people choose another way of traveling (Perry, 2020).

Not all people accept these services; they are associated for many people with kind of instability, doubts, uncertainty about the future. It is natural that not all people take the new ideas. Many people perceive the introduction of innovations and changes as a destruction of well-working system, and they do not think, that these innovations can guarantee the same level of comfort and stability which they got with the previously existing system (Barba, 2016).

Therefore, it is very important to determine the attitudes of the population towards the carsharing services. The determination of the factors having the positive impact on the development of these services, could be used by companies for improving the cost efficiency, since they can determine the costs which facilitate the usage of carsharing services.

3. Methods

3.1. Data Collection

The preliminary research of the scientific articles and semi-structured interviews with the owners and top managers of carsharing companies allowed the authors to determine the questions for surveying the respondents. In total, 23 questions were offered to the participants from Riga and Jurmala cities (Latvia), and they finally formed five constructs for PLS-SEM analysis application. A 5-point Likert scale was applied for processing the obtained survey results. The questionnaire was distributed in three languages (English, Russian and Latvian) via the social networks.

The respondents were both people with (180 people, or 80%) and without (46, or 20%) experience in using car sharing services; in total 226 respondents participated in survey, the age of respondents was from 18 to 68. 116 (51%) of respondents were female and 110 (49%) were male people.

3.2. Model

Based on the obtained results of a survey, the constructs were formed, and four hypotheses were formulated:

H1. Convenience has positive impact on increased demand on carsharing services.

H2. New Way of Thinking factors have positive impact on increased demand on carsharing services.

H3. Economic factors have positive impact on increased demand on carsharing services.

H4. Additional values have positive impact on increased demand on carsharing services.

The conceptual structure of the model of the study is presented in Figure 1.

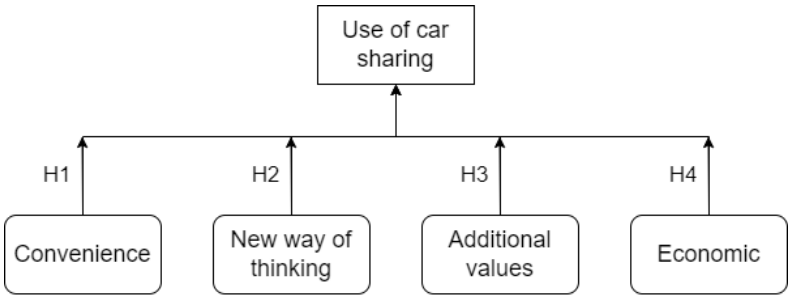


Figure 1. The proposed conceptual model of the research. (Source: figure was generated by the authors)

Therefore, there were created 5 constructs. The dependent construct "Growth of carsharing services" includes the factors demonstrating the wish and readiness to use actively the carsharing services. Four independent constructs were formed. The construct "Convenience" comprised the factors of using the carsharing services in a more convenient way compared to the private transport. Next construct, "New Way of Thinking", is absolutely contemporary one. It includes the indicators which reflect the new attitudes towards the processes in society, new thoughts about environment and ecology, wish to correspond to the sustainable trends existing in society. The construct "Additional Values" comprises the attitudes to the additional services, which customers can receive from carsharing companies beyond just simple transportation.

3.3. PLS-SEM Analysis

The authors have chosen PLS-SEM technique, which assumes to have a good causal-predictive force (Chin *et al.*, 2020, Hair *et al.*, 2021). This analysis allows simultaneous study of several statistical relationships, combining a regression-based path analysis and analysis of the most important components (Mateos-Aparicio, 2011). PLS-SEM is oriented on exploration of the theoretical issues (Garson, 2016). Employment of PLS-SEM allows forecast of the behaviour of the constructs used in the research (Schlägel and Sarstedt, 2016). Moreover, this technique is used for determining the moderating effect (Ringle *et al*., 2020) which will be applied in this research for variable "gender". Another important factor for choosing this type of analysis is the fact, that it is preferred by many scientists working in innovative fields (Wang *et al*., 2016 Shujahat *et al*., 2018; Valaei *et al*., 2017)., and carsharing is one of such fields.

The model was constructed using the software Smart PLS-3.3.7. PLS-SEM. The statistical significance α was taken at the value of the criterion $p < 0.05$. The number of iterations was 8.

3.4. Research Process

The model analysed with employment PLS-SEM techniques consists of outer and inner models. The first step is to evaluate the outer model by determining the reliability and validity of the constructs. The measurements of the outer model comprise testing the indicators of the construct for loadings/weights Rahi (2022), then the internal consistency and discriminant validity are measured (Hair *et al*., 2019; Sarstedt *et al*., 2017)

The second step is measuring the inner model, which presupposes predictive relevance and path coefficients at (Wang *et al*., 2016) and the interpretation of the structural model (Ringle *et al*., 2015).

All the indicators with factors weights/loadings lower than 0.50 were removed from the model. For example, Hair *et al*. in (2019) used even stricter criterion—loading must be more than 0.708. However, the elimination of the factors with loadings between 0.5 and 0.708 does not increase CR, and in this case, it is possible to continue using them in model (Henseler *et al*., 2009).

The Variation Inflation Factor (VIF) was applied for measuring the multicollinearity. Sarstedt *et al*. (2014) offers the criterion threshold of 10.00, but in this case the factors were not more than 1.556.

The internal consistency was measured with Composite Reliability (CR). This measure is rather liberal criterion for measuring reliability (Garson, 2016; Wang *et al.*, 2016). The values of CR, according to different scholars, may be different for different types of researches. This research is an exploratory one, and CR should be more or equal to 0.6 (Garson, 2016; Chin, 1998; Höck *et al*., 2006). Nevertheless, the obtained results could satisfy even the criterion for supporting the existing ideas but not exploratory one, all the CR values are above 0.7 (Mateos-Aparicio, 2011) or even more than 0.8 (Daskalakis *et al*., 2008; Wong, 2019).

Next measure is discriminant validity, demonstrating that the variables are distinct. There are three methods for measuring the discriminant validity, provided by SmartPLS software: Fornell–Larcker criterion, cross loadings and HTMT (Henseler *et al*., 2015); all three measures are applied in this study.

Next stage is testing the hypotheses. First there was measured the direct effect of independent constructs on the dependent one. Further the mediating effect of gender was checked. The determined path coefficients (betas) and p-values and t-statistics allow judging about the impact on dependent variable.

4. Research results

4.1. Outer Model Testing

The measurements of the outer model demonstrate the high quality of constructs used for estimation of the inner model and for testing the hypotheses.

First, the weights/loadings of all indicators were measured, and the indicators with loadings below 0.5 were removed. Employment of the PLS algorithm allowed measure other important indicators (see Table 1).

Table 1. Measurement values for inner model (Source: figure was generated by the authors)

Construct	CR >0.6	Sample Mean	STDEV	T-Statistics	p-value
Additional Values	0.772	0.762	0.039	19.558	<0.001
Convenience	0.759	0.723	0.106	7.142	<0.001
Economic	0.871	0.856	0.077	11.254	<0.001
Growth of car sharing	0.715	0.691	0.090	7.976	<0.001
New way of thinking	0.806	0.785	0.068	11.787	<0.001

Another important measure of outer model is Discriminant Validity, demonstrating the difference between the constructs within the model. Three methods – Fornell–Larcker criterion, Cross-loadings and the Heterotrait–Monotrait ratio of correlations (HTMT) – are applied in PLS-SEM analysis. Fornell–Larcker criterion is assumed as not powerful enough, demonstrating inefficiency and exaggerations in the process of determining the discriminant validity (Hair *et al*., 2017b; Rönkkö and Evermann, 2013). The Heterotrait–Monotrait ratio of correlations (HTMT) method is supposed to be the strictest criterion, and it is highly advised for employment for within PLS-SEM analysis (Henseler *et al*., 2015; Hair *et al*., 2017b).

The authors used all three criteria, and they all demonstrated the high level of discriminant validity. The results of applying the strictest criterion HTMT is shown in Table 2.

Table 2. The results of application of the Heterotrait–Monotrait ratio of correlations (HTMT)
(Source: figure was generated by the authors)

	Additional Values	Convenience	Economic	Growth of car sharing	New way of thinking
Additional Values					
Convenience	0.425				
Economic	0.550	0.285			
Growth of car sharing	0.840	0.826	0.626		
New way of thinking	0.539	0.530	0.418	0.599	

4.2. Inner Model Testing

The relations between the constructs of the model are described by the inner model. The model was constructed within 8 iterations, which is admissible result, since it is within ten iterations (Ringle *et al*., 2005; Hair *et al*., 2017b).

At the first stage of investigating the outer model the relationships determined by conceptual model of the research (see Figure 1) were tested. Then the moderating effect of gender was applied to the model.

The obtained structural model is demonstrated in Figure 2.

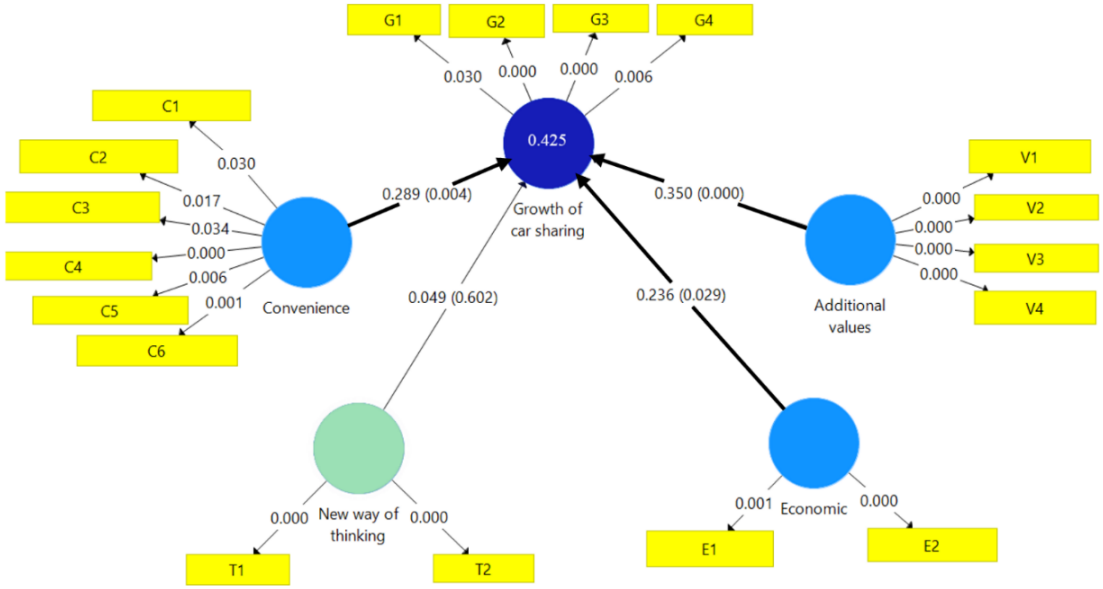


Figure 2. Structural model of car sharing services growth
Source: generated by the authors based on PLS-SEM analysis conducted in SmartPLS-3.3.7

The model comprises outer and inner measurements. The weights/loadings of the indicators are above 0.5 the values on the arrows from constructs (circles) to indicators (shown in yellow rectangles) show p-values. As it can be seen, all p-values are below 0.05, supporting the idea that the variables are well-constructed. The arrows between circles demonstrate the inner model relations. Blue circles are the constructs having impact on the dependent variable. The arrows between these constructs are highlighted. The betas are shown on arrows. The values in parentheses on the arrows are p-values. All blue circles demonstrate that the constructs have the positive impact on dependent variable. The green circle demonstrates the construct with p-value significantly higher than 0.05, therefore, the effect of this variable cannot be accepted. The dependent variable is shown in dark-blue colour. The coefficient of determination R^2 (value in the centre of dark-blue circle) is 0.425, meaning that 42.5% of model are explained by the variables. According to (Hair *et al*., 2014) and (Chin, 1998), this value is above the average one, and shows rather good result of the model.

The moderating effect of gender was not detected. However, the contained results of model evaluation allow testing the set hypotheses. The obtained results are demonstrated in Table 3.

Table 3. Estimation of direct effect (Source: figure was generated by the authors)

Effect	Path coefficient (β)	Sample Mean	STDEV	T-Statistics	p-value
Additional Values	0.350	0.350	0.099	3.548	<0.001
Convenience	0.289	0.313	0.101	2.876	0.004
Economic	0.236	0.232	0.108	2.187	0.029
New way of thinking	0.049	0.067	0.094	0.522	0.602

Therefore, it can be concluded that for these data three hypotheses of four were not rejected: H1, H2, H3, and hypothesis H4 was not accepted (with significant level equal to 0.01). The results of testing the hypotheses are demonstrated in Table 4.

Table 4. Hypotheses testing (Source: figure was generated by the authors)

Hypothesis	β	T-Statistics	p-value	Result
H1. Convenience has positive impact on increased demand on carsharing services	0.350	2.876	0.004	Not rejected
H2. New Way of Thinking factors have positive impact on increased demand on carsharing services	0.289	0.522	0.602	Not accepted
H3. Economic factors have positive impact on increased demand on carsharing services	0.236	2.187	0.029	Not rejected
H4. Additional values have positive impact on increased demand on carsharing services	0.049	3.548	<0.001	Not rejected

Therefore, it is possible to summarise that such factors as Convenience, Economic possibility to save, and Additional Values have significant impact on growth of demand on carsharing services. The new way of thinking has no impact on the development of carsharing services. The owners of the carsharing companies assume such components as green thinking, the ideas of sustainability and wish of people to make the urban environment cleaner and more comfortable are important; nevertheless, these ideas do not influence the private choice of consumption of urban population.

However, it is important to understand whether the costs of the carsharing companies correspond to the obtained results. On this purpose the costs function of carsharing company was developed, based on the semi-structured interviews with the owners of carsharing companies in Riga.

4.3. Costs Function

The costs are calculated according to the following function (Zhilenkova *et al*., 2019):

$$TC = f(IC, OC), \quad (1)$$

where IC is initial investments; OC is operational costs per year for performing the carsharing services.

Each type of costs can be represented by some elements. The initial investments are very significant, and they are represented by cost of leasing, licenses and permissions and software.

Therefore, the initial investments can be presented as follows:

$$IC = y(C_1; C_2; C_3), \quad (2)$$

where C_1 is the costs of vehicle leasing, C_2 is cost of licenses and permissions per year, and C_3 is the cost of software.

The operational costs OC for carsharing company include wages, insurance, labour training, vehicle maintenance, repair, refuel or charging, "green" promotion, advertisements. We also introduce the category "Other costs" since the companies have costs which are very important for them but cannot be represented by special category, for example, costs of office maintenance are included there. Operational Costs for the companies present substantially more complicated function, though the authors present the simplified function of costs, since there is no task to present the detailed function within the frameworks of the article.

Then, the function of operational costs is as follows:

$$OC = z(L_1 k; L_2; L_3; L_4; L_5; L_6; L_7; L_8; L_9; L_{10}; L_{11}), \quad (3)$$

where L_1 is cost of insurance, L_2 is wages, L_3 is the costs of labour training, L_4 is the costs of vehicle maintenance, L_5 is the costs of damage repair, L_6 is the costs of refuel or charging, L_7 is the costs of

advertisement, L_8 is the costs of "green" promotion, L_9 is cost of parking in the city, L_{10} is the costs of creating additional values for the customers, such as delivery of the car to the point of use or delivery the car from other countries in case of using them for international trips, L_{11} is other costs.

Three types of costs have dependence on other factors.

L_1 is determined by cost of insurance K and k; k shows the dependence on the strictness of rules of carsharing services, produced by companies; k takes values from 0 to 1, the stricter the rules – the closer the value of k to 0; the closer k is to zero, the low the value of insurance.

$$L_1 = \varphi (K; k), \text{ where } k \varepsilon [0;1]. \quad (4)$$

The costs of labour training L_3 depend not only on training costs itself, but also on the time spent by employees, we can separate this type of operational costs into special function:

$$L_3 = \mu (T; L_2*n*m), \quad (5)$$

where T is the cost of training, coefficient n demonstrates the dependence on wages, and coefficient m represents the time spent on training by employees.

Costs of repair depend on the type of damage; here we introduce the coefficient R for repair costs and d, taking the values from 0 to 1. The more serious damages the car has, the closer the value of d to one and the higher the costs of repair are.

$$L_5 = \sigma (R; d) \text{ where } d \varepsilon [0;1]. \quad (6)$$

Therefore, the final function of operational costs is as follows:

$$OC = z (\varphi(K; k); L_2; \mu (T; L_2*n*m); L_4; \sigma (R; d); L_6; L_7; L_8; L_9; L_{10}; L_{11}). \quad (7)$$

The developed costs functions demonstrate that companies in most cases have the cost structure facilitating the growth of demand for carsharing services. Nevertheless, the companies pay a lot of attention to the promoting the idea that carsharing is green and sustainable way of living in urban environment. As PLS-SEM analysis has demonstrated, it is not so, and this type of costs can be excluded. This exclusion will decrease the costs of the company without significant impact on the demand for the services.

5. Conclusions

The research reveals the factors which have the special impact on growth of demand on carsharing services in smart sustainable city. Carsharing services have very important effect on the development of smart sustainable city, their growth could contribute to all spheres of smart city: they create favourable living environment for city residents, preserve the ecological situation, decrease the traffic load, allow efficient allocation of resources.

The companies producing such kind of services are the constituent art of smart, sharing and sustainable economy. It is important for the national economy as well as for the local municipal one to develop these services. Therefore, the various stakeholders can gain from the developed study.

The research comprises PLS-SEM analysis performed in SmartPLS-3.3.7 software. First the outer model was tested. All the indicators demonstrate the high quality of model: indicators weights/loadings, Composite Reliability, Discriminant validity, Collinearity statistics. The set hypotheses were tested with inner model measurements. The model explains 42.5% ($R^2 = 0.425$), and the direct effect is not rejected for three constructs: Additional Values ($\beta = 0.350$, $p = <0.001$), Convenience ($\beta = 0.289$, $p = 0.004$), Economic factor (saving) ($\beta = 0.236$, $p = 0.029$). The hypothesis that the variable "New Way of Thinking" has significant impact on growth of demand of carsharing companies was rejected ($\beta = 0.049$, $p = 0.602$). The moderating effect of gender was not revealed.

The Costs function of carsharing companies was developed. As a result, after provided analysis, it was demonstrated that the companies can improve their efficiency. They have rather substantial costs for promoting the "green" way of operating. However, the new way of thinking of population of Riga is overestimated. The people have changed their attitudes, they think about environment and social way of living, but mostly these categories are still theoretical for many residents. When they make an economic decision, they orient first of all not on sustainable component but on additional values which are created by carsharing services, convenience of these services and the saving effect which they produce. Therefore, the company can concentrate mostly on these components in the structure of their costs. The expenditures on the promotion of green behaviour can be reduced without impact on the demand for carsharing services. Moreover, these expenditures can be redistributed. The most impact has the variable

"Additional Values", and companies can redistribute their expenditures for creating the additional values, or for example, for creating more factors of convenient use of services.

This study can present the certain interest to local authorities; they are responsible for creating the conditions for the development of smart sustainable environment within the city. Relating this research, they can help the carsharing companies in increasing the convenience for the customers of these companies. People appreciate the possibility to have parking in the places which are usually occupied, and municipal authorities can issue the additional parking permissions and allow them creating the new parking lots, which is not allowed now; people appreciate the possibility to park the car in the most expensive places without additional payment, for example, in the airport, and the local authorities should consider this fact – they are the party which gains with the development of carsharing services, which solve serious problems of urban environment.

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