Sharing economy in the smart city development

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Abstract. The concept of the sharing economy developed in the last decade is vastly underestimated. The study aims to substantiate the potential of the sharing economy in the development of smart cities. Based on a bibliometric analysis of research publications, it is shown that the concepts of the sharing economy and smart cities intersect in such areas as sustainable development, digital technologies, and the development of public goods. Three regression models have been built. We prove that the key parameter for the development of services of the sharing economy is the availability of free and fast access to the Internet. The development of some services, in particular, carsharing, was found to be dependent on the size of the city, which explains the expediency of its development only in large cities and nearby territories. It is also shown that the impact of bicycle rental services, as well as digital platforms of the sharing economy does not depend on the city size and can be used to develop the public goods sector, as well as ensure sustainable development, respectively. In conclusion, using the case of Moscow and Saint Petersburg, we demonstrated that the development of these services was not stable.

Key words: Smart city; Sharing economy; Digital technologies; Carsharing; Sustainable development.

1 Introduction

"Smart city" and "sharing economy" are concepts that are being actively developed in the last 10 years in international practice. These concepts are based on the idea of a more efficient use of resource and call for an appropriate level of digitalization. It is important to note that the principle of sharing is not new, but it reveals new opportunities for social exchange in the changing economic, social and ecological conditions. At the same time, according to some approaches, the sharing economy is considered as a component of the circular economy, what confirms its contribution to addressing the task of more efficient exploitation and distribution of resources [1, 2]. However, some studies show that these concepts have different incentives for development [3].

A more detailed analysis of the sharing economy reveals that economic, social and environmental aspects of the development of this business model should be noted [4]. From an economic point of view, the sharing economy set up new forms of enterprises as well as additional sources of income. An environmental perspective is that the sharing economy,

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through the pooling of resources, contributes to solving the climate changing problem. The social perspective is about creating and strengthening social ties and forming communities focused on more efficient resource using [5].

Thus, the sharing economy that has economic, environment and social influence and is based on digital technologies, can be used for ensuring sustainable development in cities. At the same time, platforms and services of the sharing economy are often underestimated. The novelty of this business model and its rapid expansion into different economic activities gave rise to resistance due to insufficient development of institutional mechanisms to ensure the regulatory process. The advantages of the sharing economy can be revealed through the development of special cooperation mechanisms implemented when applying this business model for the urban environment development.

Thus, the aim of this study is to substantiate the potential of the sharing economy in the development of smart cities. To achieve the aim of this study, an analysis of the research literature on this topic was carried out; indicators characterizing the sharing economy in the assessment of smart cities were analyzed; regression models showing that access to high-speed Internet was a key parameter for the development of these services were built; the dynamics of the identified indicators in Moscow and Saint Petersburg were shown.

2 Sharing economy in the context of smart cities development

The concepts of "smart city" and "sharing economy" are two key trends of the fourth industrial revolution. On the one hand, they were formed independently; on the other, they can be used together, in particular, to ensure socially significant tasks. The concept "smart city" began to be used in scientific literature in the in the nineties of the 20th century. When disclosing this term, as a rule, researchers note two key aspects: 1) the application of information and telecommunication technologies (ICT); 2) improving the efficiency of the urban infrastructure utilization. At the same time, in the course of developing research on this topic, the role of human and collective capital for the development of urban agglomerations is also highlighted [6]. According to Giffinger et al. [7], "smart city" implies a "smart" combination of abilities and activities of self-reliant, independent and conscious citizens. When studying this concept, Nam and Pardo singled out the institutional component in addition to the digital and human components [8]. In this study, we define the «smart city» as a concept of city governance based on the application of digital technologies, taking into account the participation of society in solving socially significant problems and aimed at improving the efficiency of urban infrastructure utilization.

The term "sharing economy" was introduced into research discourse by Lessig as opposed to "commercial economy" [5]. The development of collaborative consumption is linked to the work of Rogers and Botsman "What's Mine Is Yours: The Rise of Collaborative Consumption" [9]. It is important to note that the sharing economy is an umbrella term, and includes various aspects: applying the access right, resource sharing, using digital platforms for communication. For example, Acquier shows that the sharing economy is made up of three overlapping "organizational cores" - the "access economy", the "platform economy" and the "community-based economy" [10]. The principle of sharing can also be applied to various types of resources: material, financial, information, labor. This variety of areas of application of this principle indicates its gradual introduction into socio-economic processes, changing the behavior of economic agents, as well as initiating the transformation of both informal and formal institutions. In addition, one of the reasons for the sharing economy development was the processes of globalization, which formed the requirements for mobility, which stimulated the development of services based on the principles of sharing in related activities.

The sharing economy development is also associated with the search for external ways to circumvent the rules of compliance in order to achieve the final result. On the one hand, this determines the presence of some lacks in existing processes. On the other hand, it permits to use new forms of interaction and form new niches [11] accelerating changes in the institutional environment.

Thus, both the sharing economy and smart cities are linked to the positions of technologies, institutions and societies. At the same time, the formation of these concepts is based on partnership and network relations. Coe et al. put it by the next way "…community partnerships, not wires, are the fibers that connect smart communities" [12]. The dominance of digital or sharing in interactions is shaping new business models and requiring specific regulatory measures. Comparing the components of a smart city (smart economy, smart people, smart governance, smart mobility, smart environment, smart living) and services of the sharing economy, Koźlak shows that all areas of sharing (accommodation, workspace, mobility and transport, financing, food, general goods, skill/talent) satisfy the tasks of a smart economy, 6 out of 7 areas correspond to "smart environment" and "smart living". Components "smart governance" and "smart mobility" correspond to 1 area of sharing [3].

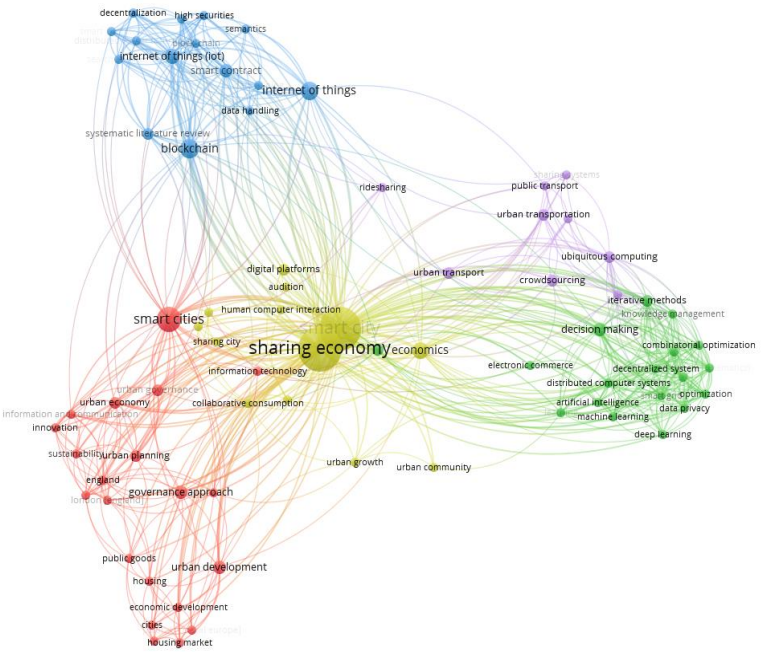


Fig. 1. Results of bibliometric analysis using the VosViewer.

A bibliometric analysis of papers indexed in Scopus showed that there were 391 publications with the keywords "sharing economy" AND "smart city" from 2014 to 2023. A more detailed analysis of these publications made it possible to select 44 publications that discuss how to use the sharing economy projects for the urban environment development. To analyze this works we used VosViewer software. Figure 1 shows the resulting map of related topics.

From the analysis of this map, four groups of publications can be distinguished. The first cluster of publications is related to the technical aspects of these concepts, in particular blockchain, network, smart contacts, etc. The second cluster concerns studies on the transport development in the urban environment, which is the fact that transport companies use this business model quite actively (carsharing, taxi, bicycle sharing, etc.). The third

cluster is crossed with the first one and includes big data processing, which is one of the key conditions that allows the sharing economy model to be applied to urban development. The fourth cluster of keywords characterizes studies that directly relates to the development of smart cities, consideration of aspects of sustainable development and public goods sector, etc.

The most cited paper [13] shows the potential of using the blockchain technology for the development of smart cities. Anthony discusses the issues associated in developing a decentralized data marketplace for smart cities suggesting recommendations to enhance the deployment of decentralized and distributed data marketplaces [14]. He notes the emergence of digital data markets, but shows that market data has security, efficiency, and privacy concerns. In addition, the problem of ensuring trust and fairness between the owners and sellers of data during their exchange becomes relevant. To solve this problem, the scientist proposes the design of an ecosystem, which consists of a data market with blockchain technology with support for telemetry transmission with message queues (MQTT), which allows to ensure trust and fairness between data owners and sellers.

Using the example of Airbnb development in London, Ferreri and Sanyal [15] show how the development of short-term rental services stimulates the authorities to develop new regulatory rules, as well as to consider proposals for the use of algorithms and big data as a means of city management.

Rahman et al. described in detail the structure of building services for the sharing economy, taking into account blockchain technologies, the Internet of Things, and artificial intelligence. With the support of the proposed infrastructure, a future smart city will be able to offer the services of a cyber-physical sharing economy through IoT data. Using smart contracts, the platform is able to provide complex space-time services on a global level without requiring a central verification authority [16].

Ferraro, King and Shorten present a scheme for applying blockchain technology as a social compliance control mechanism in smart city environments [17]. Akande, Cabral and Casteleyn in the analysis of predictors of the sharing economy development revealed that economic benefit is one of the key factors for participants in the sharing economy. However, sharing property with strangers comes with some risk, which negatively impacts people's propensity to share [18]. Kowalska and Wolniak show that certain forms of the sharing economy function best in large cities. An obstacle to the development of the SE is the non-market placement of goods and services and a strong attachment to private property.

In addition, such a concept as a sharing city is discussed in the scientific literature. An important role in the implementation of both concepts is played by citizens (bottom-up approach) and the social capital [8, 19]. Zvolska et al. [19] consider the potential of city sharing using experience of Berlin and London. The authors show that both cities indirectly support city sharing through smart agenda programs that promote ICT-enabled tech innovation and start-ups. However, there is the lack of programs, policies, support measures and regulations that directly target urban resource sharing initiatives. In addition, public authorities in Berlin are skeptical of organizations for the sharing of urban resources, while London is more loyal.

Communication and social participation are important in the processes of integration of local communities, local development and city management. Continuing this theme, Bernardi and Diamantini [4] explore how local governments manage the sharing economy to form a sharing city. Using the analysis of Milan and Seoul, the authors show that both cities are developing three key dimensions (economic, technological and human) of the sharing paradigm to create a common city. While choosing different approaches, institutionalized cooperation mechanisms remain common.

Jonek-Kowalska and Wolniak formulated and tested three hypotheses about the impact of the city size and per capita income on the municipal support for the sharing economy. In addition, the authors have verified if the degree of municipal support affect the differentiation of the implemented forms of the sharing economy [20].

Noesselt presents the Chinese experience of sharing economy regulation in smart cities and shows that regulation efforts, contrary to conventional top-down steering approaches, rely on central-local collaboration and network coordination that involves a number of multiple actors operating under the 'shadow of hierarchy' of the central party-state [21].

Using similar queries in Russian Science Citation Index, it was found 16 publications that highlight the application of sharing economy projects for the design and development of smart city environment. These publications can be divided into two groups: 1) publications related to the organization of a "smart city" based on the principles of sharing, 2) publications covering the application of sharing economy services for the development of the urban environment.

So, Vulfovich call into question if it is necessary to develop city governance system as a "platform" for the interaction of multiple actors that have a real impact on the life processes in the city and the quality of life of residents [22]. Buletova and Sokolov highlight how smart city technologies effect the development of the transport in million-plus cities in Russia [23]. The authors note that the effects of the introduction of smart city transport technologies in Russian million-plus cities can consist of improving the environmental and transport safety of living, the emergence of new jobs through the development of services and sectors of the sharing economy, the growth of initiatives coming from public groups, the inclusion of cities with the active development of smart city transport technologies in national and international economic projects that allow for high growth rates of gross regional product and expansion of markets for products and services of the regional economy, etc. [23].

3 Methodology

At the first stage of the study, we identified what data is available to measure the sharing economy at the smart city level. For this analysis, the IMD Smart City Index [Smart City Index, 2021. Available at: https://imd.cld.bz/Smart-City-Index-2021/6/] was used. Data for 2021 were used. The authors of this index took into account three indicators that characterize the services of the sharing economy. The initial data used in this study are presented in Appendix.

This index is based on the assessment of citizens and their agreement with certain statements. Components of smart city development are evaluated in terms of technology and structure. Thus, when calculating the index, such components as Health and Safety, Mobility, Urban Development (parks, bars, museums), Opportunities (Education and work), Governance were evaluated. Also, a list of problems that respondents identified in each of the cities was shown separately.

As an example, in the "Mobility" component there are two points from the "structure" direction, including the degree of consent of citizens that "Traffic congestion is not a problem", "Public transport is satisfactory". In the "technology" direction, the mobility component includes 1) "car sharing apps have reduced congestion", 2) "apps that show free parking space have reduced travel time", 3) "bike rentals have reduced congestion", 4) "Online planning and ticketing has made public transport easier." Questions 1 and 3 are related to the sharing economy.

Another question characterizing the sharing economy is also placed in the "technology" direction: "a website or application allows residents to easily give away unwanted items."

In the direction of "structure" it corresponds to the question: "processing services are satisfactory."

Another question of this study also show how Internet technologies can be used for the development of public goods, communication with authorities, however, they were not directly attributed to the sharing economy.

At the second stage, a correlation analysis was carried out to determine the impact of individual characteristics of a smart city on the development of the sharing economy. This analysis made it possible to form a set of factors that influence the development of the services of the sharing economy mentioned above.

At the third stage, through regression analysis, it is shown how individual services of the sharing economy are related to the parameters of smart city development. As a result, three regression models were built that describe the impact of smart city parameters on the sharing economy development. At the end, the dynamics of the development of these services in Moscow and Saint Petersburg is presented according to the data for 2019-2021.

4 Results

The correlation analysis showed that there are some parameters that really affect the sharing economy indicators. The list of them include assessment of citizens of the statement 1) “a large proportion of everyday payment transactions are non-cash”; 2) “free public Wi-Fi has improved access to city services”, 3) the current speed and reliability of the Internet correspond to the needs of the connection; 4) "processing services are satisfactory" [This indicators were presented in the Smart City Index 2021. URL: https://www.imd.org/smart-city-observatory/home/].

In general, the results obtained are quite expected, correspond to theoretical studies and confirm both the role of IT technologies and other digital solutions in the development of a smart city and sharing economy projects, and reveal the potential of sharing economy projects to solve public sector problems.

The results of the regression analysis made it possible to form three models. The first model has the following form (1, Table 1):

$$Y_1=0.27X_1^{0.98}X_2^{0.063} \quad (1)$$

$$(R^2=0.43.\ p<0.001)$$

where Y_1 is citizens' assessment of the statement "Car sharing apps reduced congestion"; X_1 is citizens' assessment of the statement "The current speed and reliability of the Internet meet the needs of the connection"; X_2 is the number of the population.

Table 1. Results of regression analysis for model 1.

Regression statistics	
Multiple R	0.65
R-square	0.42
Normalized R-square	0.41
Standard error	0.19
Observations	101

ANOVA analysis

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.63	1.32	35.48	2.56E-12
Remainder	98	3.64	0.037		
Total	100	6.27			

	Coeffic.	Stand. error	*t*-statistic	*P*- value	Low. *95%*	Up. *95%*
Y- inter.	-1.35	0.26	-5.27	8E-07	-1.86	-0.84
Ln(X_1)	0.98	0.14	6.968	3.74E-10	0.703	1.263
Ln(X_2)	0.063	0.016	3.929	0.000159	0.031	0.095

This model shows that a favorable impact on the development of the city's infrastructure, in particular, road congestion, is determined not only by the availability of information and communication technologies, but also by the population. This fact confirms the presence of carsharing mainly in large cities.

The second model characterizes the role of bicycle sharing that is in reducing traffic congestion (2, Table 2).

$$Y_2=0.83X_1^{0.93} \quad (R^2=0.5.\ p<0.005) \tag{2}$$

where Y_1 is citizens' assessment of the statement " bike rental reduced congestion"; X_3 is Citizens' assessment of the statement "Free public Wi-Fi has improved access to city services."

Table 2. Results of regression analysis for model 2.

Regression statistics	
Multiple R	0.71
R-square	0.50
Normalized R-square	0.49
Standard error	0.19
Observations	101

ANOVA analysis

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.54	3.54	98.97	1.42E-16
Remainder	99	3.54	0.04		
Total	100	7.07			

	Coeffic.	Stand. error	*t*- statistic	*P*- value	Low. *95%*	Up. *95%*
Y inter.	-0.18	0.056	-3.17	0.002	-0.29	-0.066
Ln(X3)	0.93	0.094	9.948	1.42E-16	0.75	1.117

This model shows that the impact of bike sharing on traffic congestion depends on the free internet access in the city. However, effect of the number of citizens has not found. So, while the development of carsharing is more appropriate for large cities, the beneficial effect of bikes sharing does not depend on the size of the city.

The third model is related to the aspect of sustainable development, in particular, with the assessment of the development of platforms that allow to give away unnecessary things. Thus, it follows that the development of ICT technologies, as well as a favorable assessment of processing services, which characterizes the city's guidelines for the implementation of sustainable development principles, contribute to the development of digital exchange and resale platforms. Here it is also advisable to talk about the inverse effect, in which sharing platforms have a positive effect on the assessment of citizens of processing services (3, Table 3).

$$Y_3 = e^{-0.17} X_3^{0.52} X_4^{0,15} \quad (R^2=0.62,\ p<0.001) \tag{3}$$

where Y_3 is Citizens' assessment of the statement “a website or application allows residents to easily give away unwanted items”; X_3 is Citizens' assessment of the statement "Free public Wi-Fi has improved access to city services"; X_4 is Citizens' assessment of the statement “processing services are satisfactory”.

Table 3. Results of regression analysis for model 3.

Regression statistics	
Multiple R	0.79
R-square	0.62
Normalized R-square	0.62
Standard error	0.10
Observations	101

ANOVA analysis

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.53	0.76	80.95	1.75E-21
Remainder	98	0.93	0.00944		
Total	100	2.45			

	Coeffic.	Stand. error	*t*- statistic	*P*- value	Lower *95%*	Upper *95%*
Y-inter.	-0.17	0.03	-5.73	1.11E-07	-0.233	-0.233
Ln(X3)	0.52	0.052	9.995	1.24E-16	0.415	0.415
Ln(X4)	0.15	0.04	3.58	0.00053	0.065	0.065

The quality of model was carried out. The multicollinearity was eliminated, autocorrelation of residuals was not revealed. The models were also tested for heteroscedasticity using a visual analysis of the residuals plot. Signs of inconsistency of the variance and dependence of the residuals were not found.

5 Discussion

5.1. Sharing economy in Russian cities

The analysis of the joint development of the s of the sharing economy sservices and "smart cities" showed that the most significant factor is the development of ICT technologies, which is a direct characteristic of both concepts. At the same time, according to the results of the index under consideration, the dynamics of indicators in Russian cities is somewhat different, which, as we see, is connected with the heterogeneity of the sharing services development, as well as, the level of social inequality. Figure 2 shows the dynamics of the considered variables in Moscow and Saint Petersburg for the period from 2019 to 2021.

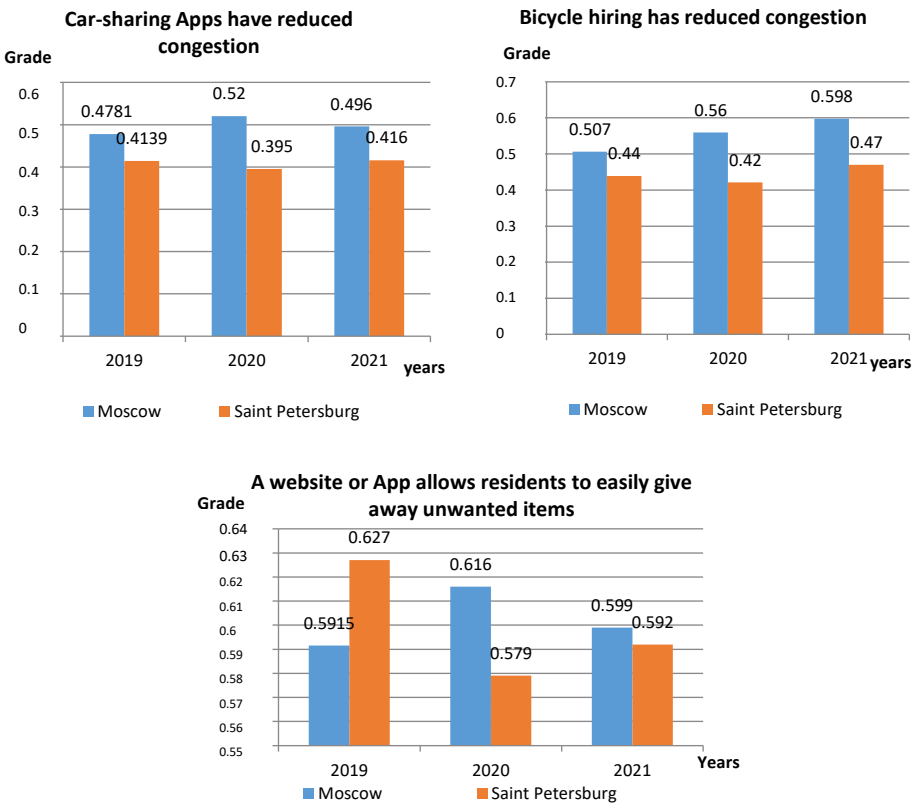
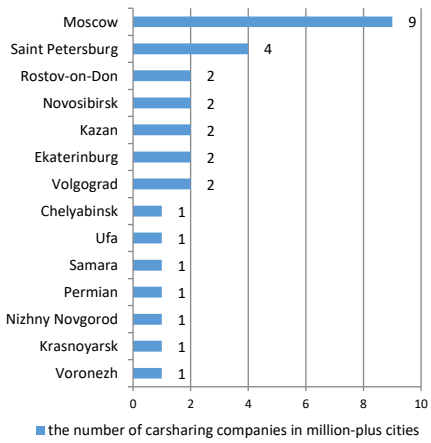


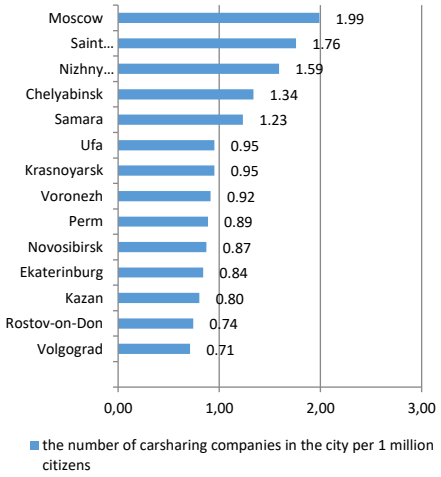
Fig. 2. Dynamics of the sharing economy indicator in the IMD Smart City Index.

Figure 2 shows that the situation in carsharing is mostly stable. There is a gradual increase in bike rental in Moscow. Saint Petersburg also have a growth, but there has been a slight decline during the pandemic period. The results for websites or applications that allow residents to easily give away unwanted items are not uniform and require additional research.

When examining the presence of carsharing companies in cities of the Russian Federation, it is clear that this type of business is developing mainly in large cities. Figure 3 shows the presence of carsharing companies in cities with a million population in absolute terms. Of the 11 cities with a population of over a million, only one city (Omsk) lacks car sharing, which is due to low taxi prices in this area. Carsharing services are also presented on tourist areas.



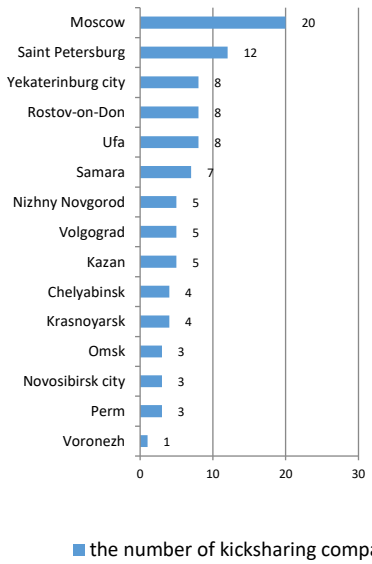
a) the number of carsharing companies in million-plus cities



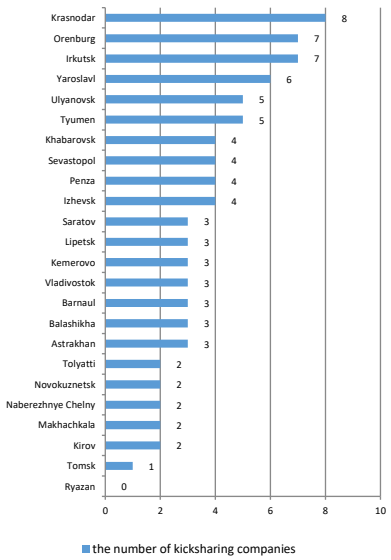
b) the number of carsharing companies in the city per 1 million citizens

Fig. 3. Rating of cities by the presence of carsharing.

A kicksharing (scooter rental) is also quite widespread, which is confirmed by the presence of this service in large cities, in cities with a population of over 100,000 people, and in cities located in close proximity to the capital of the region. Figure 4 shows the rating of million-plus cities and cities with a population of 500,000 or more.



a) the number of kicksharing companies in million-plus cities



b) the number of kicksharing companies in cities from 500,000 to 1 mln citizens

Fig. 4. Rating of cities by the presence of kicksharing.

5.2. The role of the sharing economy in solving social problems

When revealing the role of the sharing economy (SE), it should be noted the connection of this business model with such concepts as "circular economy" and "collaborative economy".

The main idea of increasing the efficiency of resource utilization, embedded in this business model, allows us to consider it as one of the elements of a circular economy (CE). The connection between the sharing and circular economy is reflected in research works. In particular, Henry presents a comparative analysis of these concepts based on bibliometric analysis [24]. The authors indeed found the connection of these concepts in the field of sustainable development, business models, sustainable consumption and management, and also confirm the nesting of the sharing economy in the circular economy. However, a detailed analysis of the circular economy and the sharing economy also shows that the goals of SE and CE digital platforms can differ [25], due to the gap between the theoretical principles of the sharing economy and practical activities. If the circular economy is more focused on the analysis of large corporations, then the sharing economy covers small and medium-sized businesses, as well as the activities of start-ups, which reflects the promise of a comprehensive study of these concepts [26].

As for as this study, websites and applications that allow residents to give away unwanted items permit them to extend the life of the product, which is one of the models of the circular economy. The carsharing and kicksharing are focused primarily on the sharing model and consumption reduction, which can also be attributed to the circular economy models [27].

Considering sharing services, in particular, in the field of transport, it is important to note that the use of this model makes it possible to reduce CO2 emissions, use resources more efficiently, thus reducing the demand for the purchase of a personal vehicle.

Whereas the connection between the sharing economy and the circular economy has common tasks and implementation goals, the collaborative economy is associated with the general principle and model of consumption, which allows revealing another side of the sharing model. At the same time, sharing and consumption concerns not only material resources, but also information, labor, and financial ones. In this context, the sharing economy goes beyond the circular economy and corresponds to an actively implemented model of sharing resource consumption on the access right. So, for example, the sharing of financial resources in the form of crowdfunding, crowdlending and crowdinvesting is an example of collaborative consymption, can have a beneficial effect on socio-economic processes, including at the city level, but is not included in the circular economy.

We should also mention data sharing and the formation of the above-mentioned concept of sharing cities, which is the development of the smart city concept, shifting the focus not only to the use of digital technologies, but also increasing the role of citizens in solving socially significant tasks, providing the required level of security, as well as the level of trust.

It should be noted that the development of the sharing economy services in the urban environment requires the active involvement and support of the authorities. In addition, the list of services and platforms presented is not exhaustive. In particular, it is advisable to consider the role of digital platforms of the sharing economy for the development of individual projects that have high social and economic significance. It seems to support the authorities in the development of investment and crowdfunding platforms that allow the release of underutilized resources and are a fairly effective tool to support small businesses, could be promising. Equipment sharing is also a rather popular tool for supporting business entities. The importance of such services is most clearly noted in the development of agriculture. The sharing economy services and related platforms provide access to expensive equipment.

Designing effective mechanisms for cooperation between authorities, formation of an institution of trust in society, as well as increasing human capital, will reduce the threats to the sharing economy development and free up additional resources to stimulate socio-economic processes.

6 Conclusion

In this study, in order to substantiate the potential of the sharing economy in the development of "smart" cities, the following results were obtained.

First, based on a bibliometric analysis of research papers, it is shown that the intersection of the study of the concepts of sharing economy and smart cities was found in such areas as sustainable development, digital technologies, and the development of public goods.

Secondly, indicators that can be used to assess the development of services in the sharing economy were identified. These indicators characterize the impact of car sharing and bike sharing on traffic congestion, as well as the assessment of citizens of sharing platforms for exchange and resale.

Thirdly, three regression models showing that the key parameter for the development of the sharing economy services is the availability of free and fast access to the Internet were built. In addition, it was found that the development of the carsharing depends on the size of the city, which explains the expediency of its development only in million-plus cities and nearby territories.

Fourthly, using data of Moscow and Saint Petersburg, it is demonstrated that the development of these services is not stable. At the same time, these data are sufficient to conclude that it is expedient to implement mechanisms for cooperation between authorities and operators of digital platforms (and services) of the sharing economy in order to improve standard of living. In addition, the paper shows the presence of carsharing and kicksharing companies in Russian cities, which shows the prospects and demand for this market. At the same time, the issues of regulating the services of the sharing economy, the development of not only norms and rules for regulating this area, but also an appropriate infrastructure remain extremely important. Thus, the presented study showed the prospects for the development of sharing economy services in order to develop a smart city and drew attention to this area of research in Russian cities. Results of this research expand theoretical studies about the role of sharing economy in economic, social and environment changes. The practical significance lies in substantiating the significance of these services for the development of smart cities.

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Appendix

Table. Used database (Smart City Index, 2021).

City	dCar	dBike	dInernet	dWiFi	dInernet	dServices	N
Abu Dhabi	0.639	0.567	0.746	0.717	0.834	0.844	1,480,000
Abuja	0.516	0.203	0.319	0.282	0.569	0.420	3,280,000
Amsterdam	0.451	0.538	0.594	0.523	0.704	0.636	1,000,000
Ankara	0.493	0.479	0.605	0.609	0.675	0.632	5,120,000
Athens	0.342	0.276	0.527	0.367	0.531	0.381	3,150,000
Auckland	0.43	0.431	0.657	0.622	0.709	0.771	1,610,000
Bangkok	0.564	0.554	0.624	0.581	0.748	0.575	10,540,000
Barcelona	0.421	0.564	0.556	0.521	0.718	0.672	1,640,000
Beijing	0.648	0.795	0.741	0.797	0.878	0.758	20,480,000
Bangalore	0.633	0.634	0.581	0.557	0.764	0.598	12,330,000
Berlin	0.358	0.440	0.624	0.492	0.559	0.701	3,670,000
Bilbao	0.425	0.618	0.546	0.584	0.760	0.743	350,000
Birmingham	0.380	0.432	0.611	0.574	0.659	0.623	1,140,000
Bogota	0.421	0.468	0.412	0.505	0.554	0.454	10,980,000
Bologna	0.445	0.565	0.577	0.615	0.587	0.488	400,000
Boston	0.418	0.430	0.553	0.515	0.656	0.682	4,310,000
Bratislava	0.397	0.494	0.530	0.622	0.677	0.508	440,000
Brisbane	0.399	0.441	0.615	0.631	0.595	0.704	2,410,000
Brussels	0.386	0.506	0.571	0.513	0.656	0.599	1,220,000
Bucharest	0.434	0.494	0.575	0.535	0.783	0.331	2,130,000
Budapest	0.373	0.474	0.561	0.527	0.659	0.558	1,750,000
Buenos Aires	0.474	0.584	0.506	0.561	0.612	0.487	15,150,000
Busan	0.410	0.361	0.584	0.740	0.756	0.699	3,470,000
Cairo	0.576	0.450	0.488	0.429	0.575	0.438	20,900,000
Cape Town	0.529	0.410	0.534	0.549	0.618	0.552	4,620,000
Chengdu	0.654	0.812	0.667	0.771	0.860	0.707	9,140,000
Chicago	0.494	0.485	0.523	0.509	0.630	0.597	8,870,000
chongqing	0.695	0.721	0.747	0.771	0.888	0.770	15,870,000
Copenhagen	0.424	0.519	0.654	0.539	0.680	0.745	1,350,000
Denver	0.432	0.412	0.600	0.461	0.625	0.641	2,830,000
Dubai	0.610	0.613	0.717	0.762	0.813	0.819	2,880,000
Dublin	0.337	0.618	0.580	0.509	0.655	0.639	1,230,000
Dusseldorf	0.401	0.490	0.552	0.550	0.60	0.733	630,000
Geneva	0.368	0.461	0.633	0.603	0.761	0.799	200,000
Gothenburg	0.317	0.448	0.548	0.568	0.706	0.682	560,000
Guangzhou	0.650	0.768	0.764	0.829	0.883	0.761	13,300,000
Hanoi	0.723	0.481	0.667	0.662	0.805	0.601	4,680,000
Hanover	0.410	0.437	0.540	0.466	0.542	0.737	540,000
Helsinki	0.352	0.607	0.669	0.550	0.728	0.764	650,000
Ho Chi Minh City	0.696	0.486	0.650	0.647	0.788	0.650	8,600,000

City	dCar	dBike	dInernet	dWiFi	dInernet	dServices	N
hong kong	0.434	0.386	0.535	0.663	0.814	0.429	7,550,000
Hyderabad	0.656	0.553	0.549	0.55	0.747	0.633	10,000,000
Jakarta	0.625	0.625	0.614	0.677	0.748	0.576	10,770,000
Kyiv	0.434	0.486	0.507	0.58	0.741	0.390	2,990,000
Krakow	0.393	0.502	0.557	0.583	0.641	0.586	770,000
Kuala Lumpur	0.602	0.462	0.521	0.570	0.613	0.534	8,000,000
Lagos	0.466	0.262	0.394	0.341	0.593	0.454	14,370,000
Lisbon	0.382	0.460	0.568	0.575	0.694	0.637	510,000
London	0.420	0.568	0.623	0.597	0.688	0.659	8,870,000
Los Angeles	0.542	0.494	0.623	0.596	0.681	0.656	12,450,000
Lyon	0.435	0.569	0.557	0.594	0.655	0.630	1,080,000
Madrid	0.535	0.597	0.619	0.575	0.763	0.616	3,270,000
Makassar	0.555	0.511	0.534	0.584	0.659	0.524	1,580,000
Manila	0.539	0.528	0.529	0.549	0.547	0.540	13,920,000
Medan	0.565	0.538	0.582	0.625	0.703	0.532	2,340,000
Medellin	0.502	0.601	0.488	0.673	0.650	0.687	4,000,000
Melbourne	0.446	0.411	0.601	0.629	0.636	0.637	4,970,000
mexico city	0.422	0.526	0.453	0.534	0.591	0.384	21,780,000
Milan	0.456	0.514	0.573	0.533	0.553	0.813	1,410,000
Montreal	0.413	0.540	0.588	0.530	0.711	0.722	4,220,000
Moscow	0.496	0.598	0.599	0.599	0.748	0.581	12,540,000
Mumbai	0.655	0.596	0.574	0.668	0.749	0.467	20,410,000
Nairobi	0.409	0.493	0.580	0.596	0.603	0.371	4,730,000
Nanking	0.453	0.241	0.398	0.414	0.677	0.779	8,850,000
New Delhi	0.781	0.840	0.782	0.827	0.769	0.626	30,290,000
New York	0.640	0.632	0.631	0.664	0.734	0.660	18,800,000
Osaka	0.557	0.585	0.595	0.654	0.698	0.615	19,170,000
Oslo	0.652	0.681	0.607	0.594	0.667	0.798	1,040,000
Paris	0.242	0.263	0.555	0.447	0.538	0.523	9,850,000
Philadelphia	0.436	0.619	0.695	0.494	0.703	0.516	5,720,000
Prague	0.422	0.541	0.640	0.528	0.675	0.683	1,320,000
Rabat	0.411	0.400	0.544	0.446	0.567	0.461	1,880,000
Rio de Janeiro	0.434	0.319	0.618	0.448	0.616	0.358	13,460,000
Riyadh	0.359	0.404	0.649	0.578	0.706	0.739	7,230,000
Rum	0.445	0.385	0.402	0.471	0.653	0.228	2,810,000
Rotterdam	0.418	0.483	0.398	0.309	0.506	0.646	620,000
San Francisco	0.672	0.493	0.694	0.644	0.792	0.300	3,310,000
Santiago	0.318	0.347	0.480	0.408	0.479	0.411	6,770,000
Sao Paulo	0.342	0.480	0.622	0.547	0.655	0.420	22,040,000
Seattle	0.458	0.470	0.559	0.478	0.650	0.739	3,430,000
seoul	0.456	0.497	0.672	0.746	0.785	0.710	9,960,000
Shanghai	0.651	0.755	0.748	0.798	0.895	0.785	27,060,000
Shenzhen	0.731	0.795	0.797	0.825	0.885	0.798	12,360,000
Singapore	0.596	0.519	0.653	0.764	0.826	0.664	5,940,000
Sofia	0.352	0.375	0.490	0.561	0.728	0.373	1,240,000
Saint Petersburg	0.416	0.470	0.592	0.587	0.744	0.497	5,470,000
Stockholm	0.286	0.360	0.639	0.511	0.677	0.705	950,000
Sydney	0.405	0.395	0.653	0.601	0.624	0.690	4,930,000
Taipei	0.586	0.679	0.670	0.785	0.750	0.836	2,720,000
Tel Aviv	0.400	0.554	0.588	0.588	0.637	0.608	4,180,000
Hague	0.359	0.469	0.558	0.532	0.651	0.678	770,000
Tianjin	0.733	0.787	0.727	0.822	0.868	0.787	13,590,000
Tokyo	0.217	0.266	0.621	0.487	0.571	0.638	37,390,000
Toronto	0.417	0.458	0.592	0.544	0.686	0.733	6,200,000
Vancouver	0.438	0.471	0.576	0.617	0.676	0.800	2,580,000
Vein	0.385	0.448	0.649	0.556	0.697	0.861	1,930,000
Warsaw	0.476	0.594	0.615	0.610	0.686	0.556	1,780,000
Washington	0.502	0.509	0.601	0.571	0.670	0.671	5,320,000
Zaragoza	0.407	0.625	0.557	0.454	0.795	0.714	670,000
Zhuhai	0.836	0.872	0.815	0.839	0.905	0.843	1,760,000

City	dCar	dBike	dInernet	dWiFi	dInernet	dServices	N
Zurich	0.424	0.514	0.559	0.529	0.773	0.867	410,000

Note:
dCar it is Citizens' assessment of the statement “Car sharing apps reduced congestion”;
dBike it is Citizens' assessment of the statement “Bike rental reduced congestion”;
dWebsite it is Citizens' assessment of the statement a “Website or application allows residents to easily give away unwanted items”;
dWiFi it is Citizens' rating of the statement "Free public Wi-Fi has improved access to city services”;
dInernet it is Citizens' assessment of the statement "The current speed and reliability of the Internet meet the needs of the connection;
dServices it is Citizens' assessment of the statement “Processing services are satisfactory”;
N it is the number of the population.

The source: Smart City Index, 2021. Available at: https://imd.cld.bz/Smart-City-Index-2021/6/