The Role of the Smart Citizen in Smart Cities

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Abstract. The exponential growth of the urban population made cities to feel the obligation to guarantee liveable conditions for all citizens who seek them. The creation of new models of cities and the interconnection between the services they offer became a pressing need. With the technological advancements, all this integration lead cities to scale to the concept of Smart City. This paper focuses on the perspective of the citizen. When asked about how smart the cities where they live, few citizens know it, and, even more, when asked about how participative they are, the answer is null or ineffective. Their perspective is being neglected in public matters, either governmental or environmental. Therefore, it is essential to carry out a comprehensive study that allows understanding how the citizen becomes an integral element of the city where he lives, studies, works, or visits. Inclusive cities use technological platforms that motivate citizens to stay or visit the city, thus contributing to citizen inclusion. It is crucial to understand the best digital approach to meet citizens' needs in the city to take advantage of what the city has to offer.

Keywords: Smart cities · Smart citizens · User experience · Human behavior · Social impact

1 Introduction

Due to the rapid growth of the urban population and the lack of natural resources, cities face several challenges that can range from technical, material, social to organizational, thus influencing citizens' quality of life. It is of most importance to develop logistical measures for the proper functioning of cities and at the same time guarantee livable conditions for all citizens. In this sense, new models of interconnection of services have become a pressing need. With the exponential evolution of technology in the recent years, cities tend to use Information and Communication Technologies (ICT) to become more attractive, sustainable, interactive, and accessible, which lead to the concept of Smart City (SC).

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According to Zubizarreta et al. [1], a SC is a constantly evolving city, using technology in its different areas of application such as economy, people, housing, governance, environment, and mobility. Moreover, a SC requires the active involvement and participation of the citizen. Although the definition of a SC is well established in the literature, there is no clear definition of smart citizens. According to Yonezawa et al. [2], an attractive city focuses on the citizen who is a crucial component to the city since he consumes what the city provides. However, it is imperative to facilitate the citizen's participation process. Mellouli et al. [3] refer that the citizen's opinion has a significant contribution to public issues, such as the development of society, the design and implementation of public policies, and decisions transparently and responsibly. Cities need to show the citizen that their involvement is relevant and positively impacts the community. To achieve this, it is also necessary to provide the citizen useful, relevant, and complete information.

1.1 Smart Cities

Citizens increasingly switch from rural to urban areas, causing rapid population growth. This implies that cities need to face issues related to governance and deficit of natural resources, which influence the future of cities and citizens.

Pellicer et al. [4] refer that, currently, the concept of SC is widely used, influencing the analysis of its meaning in different perspectives. Although there are multiple definitions, the authors state that a SC is an urban system that uses ICT to make its infrastructures and public services more interactive, accessible, and efficient, so it must be able to efficiently manage its infrastructure and services, taking into account the needs of the cities and their citizens. Kumar and Dahiya [5] state that SC are composed of six fundamental areas: smart people, smart economy, smart mobility, smart environment, smart housing, and smart governance. Intelligent people are the critical element of cities because their participation is essential for a sustainable development. Joss et al. [6] believe that it is not enough to make incremental improvements in the management of cities, and claim that city leaders should identify and implement radical and transformative solutions. They describe new approaches to the city management and consider that the development of technologies provides new and useful tools, creating more significant opportunities for citizens, companies, and other organizations to implement the required changes. Examples of these management tools include parking, traffic, air quality, water consumption, and urban waste. In terms of parking management, Lu et al. [7] developed an intelligent parking system (SPARK) which provides information to the user in real-time of empty parking lots. The system also provides an anti-theft protection service, by detecting if the vehicle leaves the parking area illegally. Another system implemented in this area is the Khanna and Anand project [8]. Their smart parking system indicates available spaces in real-time, and allows the user to reserve a parking space for a period of time.

The increasing number of vehicles circulating in cities causes traffic congestion, an increase in the number of accidents, and high fuel consumption.

Kanungo et al. [9] calculated traffic density in real-time using cameras to allow the automatic management of traffic lights, improving the fluidity of traffic. In this context, Ghazal et al. [10] developed a system that allows the traffic lights to be switched depending on the traffic density. This system complements with a portable controller for priority vehicles stuck in traffic. The vehicles communicate through a wireless system, XBee, to activate the emergency mode. Air pollution is a global concern in the management of air quality due to citizens' exposition to air pollutants. AirSense is an air quality detection system presented by Dutta et al. [11] consisting in the aggregation of data from sensors to infer air quality. Through a heat map, citizens can view the city's air pollution and the air quality index of his location. The captured data can alert the citizen to make decisions about how to improve the environment. Regarding water, within cities, there is a growing concern for its efficient management. To ensure that water is properly supervised, Shahanas and Sivakumar [12] propose an intelligent water management system using IoT. It includes sensors that measure several tanks' water level in real-time, with observable information generated on a web platform. Also, the system allows the reception of alerts through SMS or email. Finally, at the level of urban waste management, there is a pressing need to reduce the stench on city streets, spread of diseases, and the reproduction of insects in the garbage due to the overflow of the containers. Sharma et al. [13] monitor the degree of filling of the garbage containers in real-time. They verify when they are full and act quickly and efficiently in their emptying. Considering the diverse works presented in the different areas of a SC, there are multiple platforms developed that help SC provide responsive services to improve their governance and citizens' quality of life. However, it is essential to have the vision of citizen participation.

1.2 Citizen Participation

According to Degbelo et al. [14], cities need to gather macro (aggregate data) and micro (citizen-generated data) observations to discover how global phenomena (transport, mobility, energy, etc.) relate to the observations of citizens. It is essential to listen to citizens' opinions, understand and act in accordance to improve the quality of life in cities. Neirotti et al. [15] claim that the population of cities with more advanced internet services makes citizens more active in launching and participating in initiatives in areas such as government and economy.

Citizen participation can provide multiple benefits to cities, such as more significant contribution to education and socialization processes, better political decisions, producing better social and environmental results [16]. However, the citizen must receive useful, relevant, and complete information to give their opinion in a meaningful way. According to Caragliu et al. [17], a way to reach out to citizens is through ICT, since they enable sustainable economic growth and high quality of life, with intelligent management of natural resources, through participatory governance. ICTs can energize the citizen so that they have direct participation in the city's sustainable growth. According to Granier and Kudo

[18], some students consider ICT a powerful means of promoting and improving public participation. These can reduce participation costs, allowing citizens to participate through their mobile devices at any time and place. The authors consider the means of expression and communication provided by ICTs as objects that allow new citizens to have an interest and legitimacy in participating in public affairs. Both students and professionals emphasize that citizens play a crucial role in SC, not only for their appropriate behavior but also for their governance participation.

This paper focuses on the citizen's perspective to improve the quality of his experience in the city. Moreover, it is measured how the different means of communication can be used to better establish a communication between the city and the citizen.

2 Materials and Methods

This section identifies the objectives and research hypothesis. Moreover, the methodological approach implemented in the different stages of the investigation, as well as exploratory research and qualitative research, is presented.

2.1 Research Goals and Hypothesis

The research goals define what is to be achieved with the research to be carried out. They are declarative statements that clarify the keywords, the target population, and the research's orientation [19]. Thus, the research goals of this paper are: (1) understand how the digital means can be used to improve the citizen experience; and (2) define the digital model that enhances the improvement of the citizen's experience in the city.

The research hypotheses are constructed to explain or understand a specific phenomenon and are guidelines for the problem to be demonstrated [20]. Notwithstanding its formulation tries to answer the formulated problem, they are assumptions as they may not be confirmed with the research results. However, they provide the research a guiding thread and criteria to select relevant data. Following the objectives of the research work, the research hypotheses are:

- H_A: The way the city communicates with the citizen influences their participation in the city
- H_B: A mobile application is a suitable digital means for citizens to communicate with the city and encourage their participation
- H_C: The type of information that the citizen seeks depends on several characteristics, such as age, profession, means of travel, and the region where he lives

2.2 Qualitative Analysis

Qualitative research is a methodology based on samples that provide an understanding of the problem context [21], and to answer research questions [22].

According to the qualitative research and the research hypotheses, the elaboration of a questionnaire is an adequate procedure to collect feedback from the target audience [20]. Wolniak and Jonek-Kowalska [23] refer that the city's quality of life is measured by implementing the ISO 37120 standard of the International Organization for Standardization that evaluates cities' performance and consists of a list of indicators. Hajduk [24] states that the ISO 37120 standard is the most practical method for measuring the city's performance.

For the formulation of the questionnaire, several research questions are defined: *Q1*: What type of information citizens look for?; *Q2*: Which means of communication influence the citizen?; *Q3*: Are citizens aware that cities are smart cities?; *Q4*: How information in public spaces influences the citizen?; *Q5*: Is environment information important for citizens?; *Q6*: Active participation rewards are important for the citizen?

3 Results

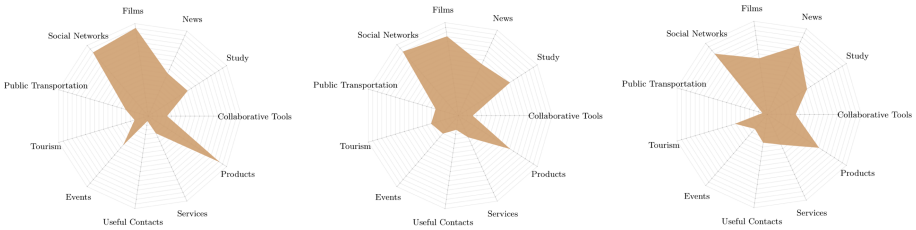
This section aims to present the results obtained from the qualitative analysis resulting from the responses achieved by disseminating the questionnaire. The study is divided into three phases: the characterization of the sample profile, the analysis of the main results, and the validation of the research hypotheses.

3.1 Sample Characterization

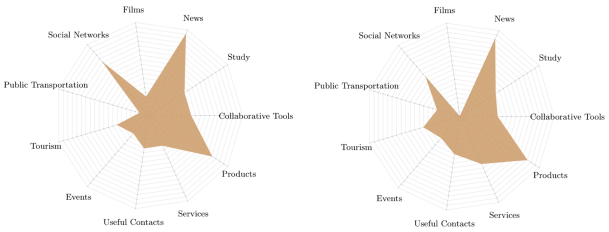
This section characterizes socio-demographic characteristics of the sample made of 387 valid answers from portuguese citizens; 55% of participants are females, and the overall ages vary from 15 to 79 years, and the most representative is between 19 to 24 years (average age of the sample is 31 years). 61% of the citizens live in the urban space and 39% in rural areas. Most citizens (91.6%) live with other people in their household. Moreover, 50.4% are employed, while 32.6% are students and 17% are retired or unemployed. The preferred means of transport is personal transport (72.6%), and the rest use public transportation or shared transport.

3.2 Influence of Information

There is a lot of information available to citizens, however not all of that information is relevant. Generally, a young citizen does not have the same interests as an older citizen. To understand these differences, Fig. 1 presents the information that groups of citizens look for according to their ages, and three major groups can be identified: under 25 years old (given by Fig. (1a) and Fig. (1b)), a transition group between 26 and 39 (Fig. (1c)), and over 40 (Fig. (1d) and Fig. (1e)). Results show that citizens have a great interest in social media, films, news, and products. Although social networks are influencers in all age groups, it tends to reduce for older citizens, as well as films. On the other hand, news and services' influence increases for older citizens.



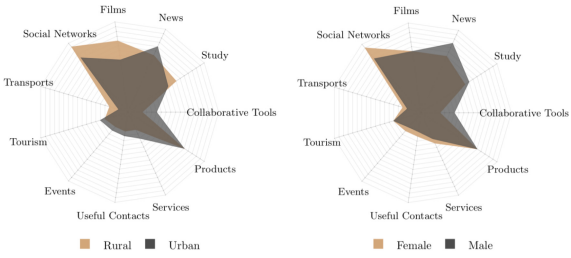
(a) under 18 (b) 19 to 25 (c) 26 to 39



(d) 40 to 59 (e) over 60

Fig. 1. Distribution of influence of information into age groups.

Considering the region where the citizen lives (Fig. (2a)), there are no representative differences regarding the interest in information. The most valued information is social media, news, buying products, studying, and watching films or series. At the gender level (Fig. (2b)), similar interests are identified. Both genders are interested in products, news, studying, and social networks. This analysis is concordant with the information inquired by citizens living in rural or urban areas, by their occupation, and age groups.



(a) Region (b) Gender

Fig. 2. Distribution of influence of information considering regions and gender.

3.3 Influence of Means of Communication

The means of communication aim to disseminate information, so cities should consider them a form of communication with the citizen. In this sense,for cities to captivate the citizen's interests, it is crucial to consider which means of communication are best received by the citizen. The means that most influences the citizens are social networks, television, websites, and mobile applications, as shown in Fig. 3.

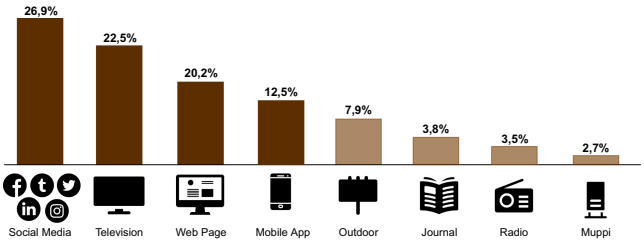


Fig. 3. Influence of different means of communication.

By considering the analysis of the region where the citizen lives, there are no significant differences. Social networks have more influence in rural areas, and the remaining media in urban areas (Fig. (4a)). When incorporating the age range, and the region where the citizen lives, it is noticeable the difference in the values. While in the rural area, television, social media, websites, and mobile apps have great influence in under 25 years old citizens. On the other hand, these values decrease in this age range and increase for other age ranges, as presented in Fig. (4b) and Fig. (4c).

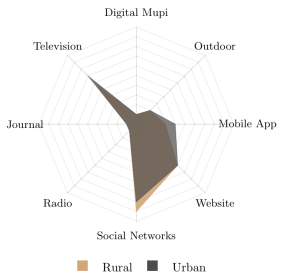
3.4 Citizen Awareness of Living in a Smart City

Due to the continuous increase in the population in cities, which makes their management difficult, they tend to use technology to guarantee a better quality of life for citizens and provide them better services [25]. With this, cities tend to become more intelligent; however, this intelligence does not always reach the citizens' knowledge. This is aligned with the results obtained in this paper, since 56% of citizens are not aware of the use of technology in cities (from these, 57% live in urban areas).

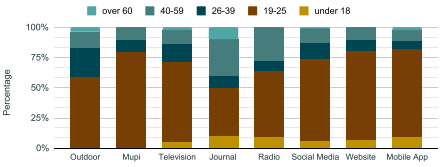
Thus, nevertheless some technologies are incorporated in cities, they do not reach public knowledge, and, thus, do not have the expected impact on citizen's lives.

3.5 Impact of Information in Public Spaces in the Citizen

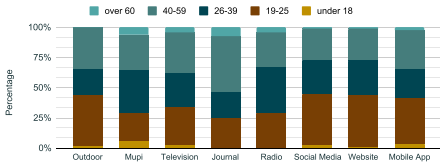
This paper aims at investigating if the means that exist in a city can influence the citizen to engage with the city. If this occurs, cites are able to capture citizen attention to promote the concept of SC. Several aspects are taken



(a) Influence of means of communication



(b) Rural age distribution



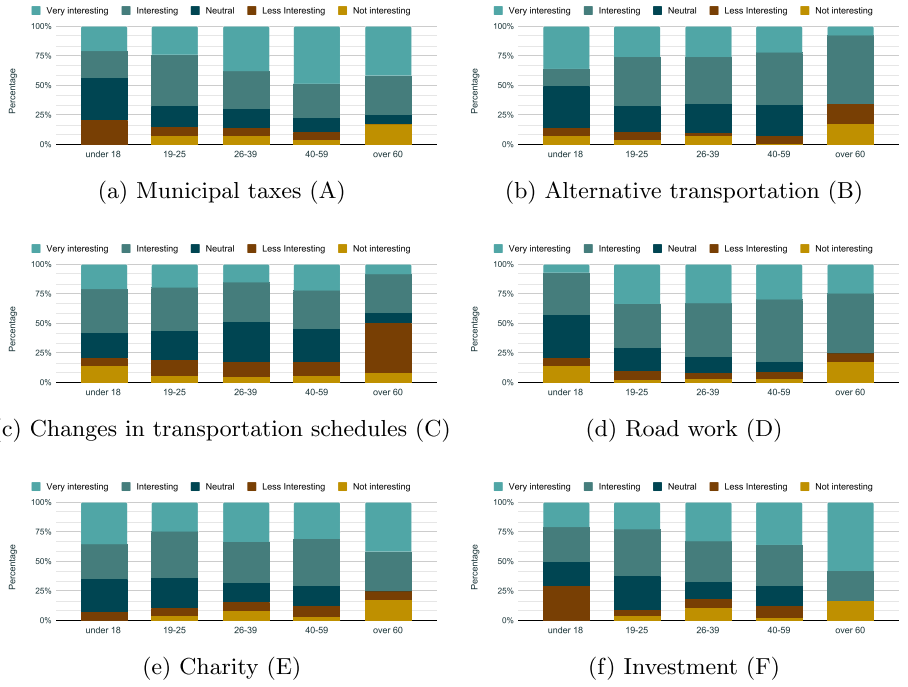
(c) Urban age distribution

Fig. 4. Means of communication in rural and urban areas.

into account: public transportation, road work, charity actions, municipality discounts or investments, with special focus on their environmental concerns. Results show that citizens are aware and interested, as presented in Fig. 5.

Due to the excessive population in cities there is an increase in waste production and resources become limited, making recycling a growing concern [26]. It is essential to raise awareness among citizens to act differently. This section examines the citizen's interest obtaining discounts for recycling actions. Figure (5a) shows that the information is considered attractive regarding discounts in municipality taxes, except for citizens up to 18 years old. The use of alternative transport is one of the environmental concerns of cities since by reducing car traffic, CO2 emissions into the atmosphere are also reduced. This study variable measures the impact on the citizens when receiving discounts by using an alternative transport. According to Fig. (5b), this information is considered important for the citizen. At another level, public transport is a means of transport used by citizens in various activities, typically managed by schedules and routes, which may change. Citizens up to the age of 59 are interested in obtaining information about public transport changes (Fig. (5c)). Citizens over 60 years of age have different opinions, which is related to the region they live in (less interest in urban citizens). Regarding the road work scenario, depicted in Fig. (5d), this information is considered of interest in all age ranges. At the donations level, it is common to see cities ask for donations to assist several charity associations. Although citizens under 25 are neutral about this subject, all the other citizens consider this information interesting, as shown in Fig. (5e). Within the scope of

citizen participation in city governance, there has been a significant increase in Participatory Budgets' participation, promoted by cities. According to Fig. (5f), citizens measured their interest in information related to the city's intervention, resulting from their action. Thus, most citizens find this information interesting at the investment level, emphasizing citizens over 60 years of age. The opinion of citizens under the age of 18 is divided.



(a) Municipal taxes (A)

(b) Alternative transportation (B)

(c) Changes in transportation schedules (C)

(d) Road work (D)

(e) Charity (E)

(f) Investment (F)

Fig. 5. Impact of information in public spaces.

In addition to the scenarios presented above, this study also considers a set of interest areas to the citizen, presented in Fig. 6. The areas of health and recreation are those that capture the attention of citizens. Advertising is the type of information that they find less interesting or feel neutral. In general terms, the traditional use of outdoors for advertising has little impact on the citizen, in this context.

When refining this analysis related to the age ranges, different results are obtained (Fig. 7). With the exception of advertising, all age ranges consider each type of information as interesting in all age ranges, with the exceptions of under 18 citizens in information regarding health (Fig. (7c)) and municipality services (Fig. (7e)). On the other extreme, information regarding sports is considered neutral for citizens above 60 years old (Fig. (7f)).

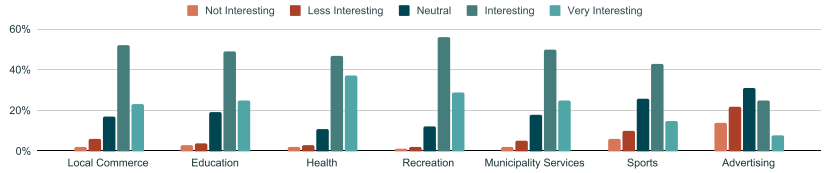
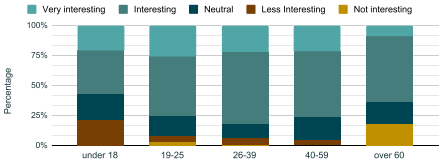


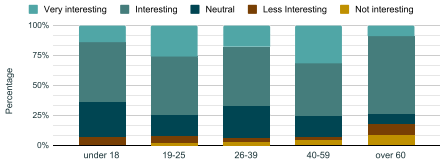
Fig. 6. Information exhibited in outdoor means of communication.

3.6 Importance of Environment

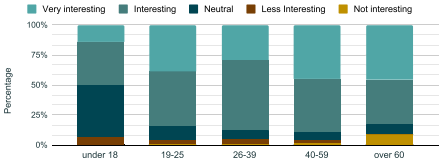
Cities regularly disseminate multiple information on different subjects, and sometimes there is information that does not attract the attention of the citizen. Infor-



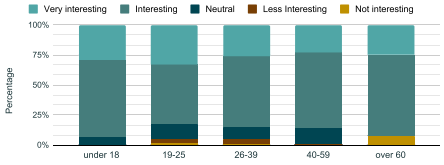
(a) Local Commerce



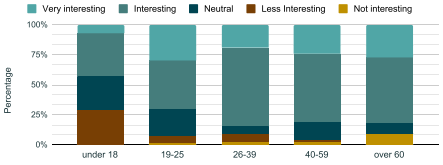
(b) Education



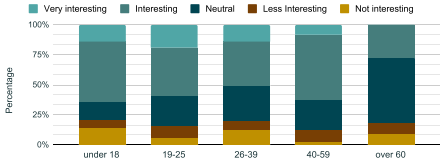
(c) Health



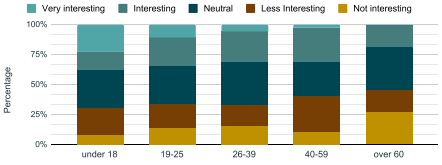
(d) Recreation



(e) Municipality Services



(f) Sports



(g) Advertising

Fig. 7. Areas of interest for the citizen by age range.

mation about the environment sometimes appears to be unappealing information due to a lack of regular dissemination. Thus, according to Fig. 8, all information is considered important, despite the significant interest in civil warnings. The detailed analysis of the interest of citizens does not vary when considering the region where the citizen lives and the age range. As a consequence of the citizen interest in environment, becomes clear that cities must take this into account. Thus, according to the qualitative research, cities tend to invest in projects that involve taking care of the environment. However, it also appears that cities need to motivate citizens to participate. Thus, the interest of offering rewards to citizens is analyzed if they perform a specific action. According to Fig. 9, rewards are a good way to captivate the citizen to this concern.

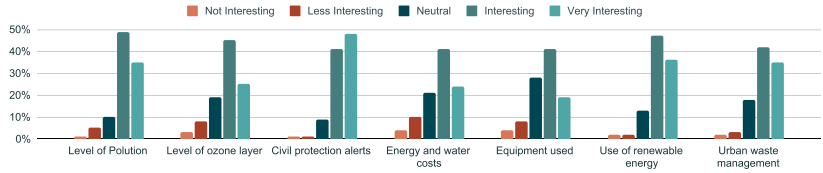


Fig. 8. Importance of environmental information.

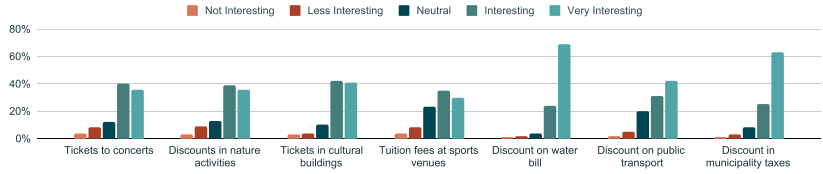


Fig. 9. Importance of rewards.

3.7 Validation of the Research Questions

After characterizing the sample and analyzing the main results, it is essential to determine the research hypotheses' integrity by executing statistical tests, ANOVA, and Chi-square, to compare the hypothesis variables and their dependence and association relationship.

***H_A* - The Way the City Communicates with the Citizen Influences their Participation in the City:** As previously referred, it is important to listen to the citizen so that the city can act to improve its life quality. For that, it is important that citizens obtain useful information so that they feel as an integral member of it. Two hypothesis have been defined: *H0*: The citizen is not interested in participating in the city through the means of communication, and *H1*: The citizen is interested in participating in the city through the means of

communication. According to Table 1, the citizen is interested in participating in the city, since multiple solutions reject *H0*. To understand the communication from the city to the citizen, the impact of the means of communication in the citizen participation is tested with the following hypothesis: *H0*: The mean of technological communication do not influence the citizen participation, and *H1*: The means of technological communication influence the citizen participation. ANOVA Results show that the outdoor is the only mean that rejects *H0* ($\sigma = 0.049 < 0.05$). Since citizens are not aware that the city uses technology to make it a SC, this is an indicator that the communication is not adequate. This way, *H1* has to be considered, since communication is of major importance in a city. In this context, citizens need to be informed about the use of technology, and the development of applications for citizens has to be preceded by a different communicational approach from cities to citizens. According to Sect. 3.4 citizens are not aware if technology is being used to make cities more smart. This implies that the communication from cities to citizens is not adequate, and citizens are not aware of what cities have to offer, which affects its participation. This has a major impact in the validation of this research question, and a recommendation for all stakeholders is presented in Fig. 10.

Table 1. ANOVA test with citizen participation and means of communication.

Solutions	ANOVA (sig. Value)							
	Outdoor	Digital Mupi	Television	Journal	Radio	Social media	Websites	Mobile apps
Register problems of the city	0.04	0.574	0.05	0.297	0.091	0.008	0.03	0.07
Report problematic locations in the city	0.880	0.550	0.418	0.138	0.143	0.01	0.049	0.096
Share information about events in open spaces	0.276	0.195	0.023	0.210	0.309	<0.001	0.077	0.047
Report Level of occupation of public trash deposits	0.032	0.043	0.024	0.789	0.347	<0.001	0.022	0.028
Share or rent non-polluent transports	0.264	<0.001	0.027	0.311	0.274	<0.001	0.081	0.088

***H_B*: A Mobile Application is a Suitable Digital Mean for Citizens to Communicate with the City and Encourage Participation:** According to Sect. 3.3, there are several means of communication that are well received by the citizen, and the mobile application is within the top means. W have tested if the other means of communication are influencers of using mobile applications. The following hypothesis were formulated: *H0*: The use of mobile application is not influenced by other means of communication, and *H1*: The use of mobile application is influenced by other means of communication.

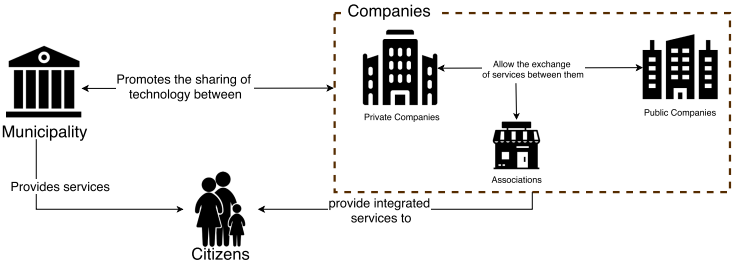


Fig. 10. Recommendation for stakeholders in a SC environment.

ANOVA results show that only radio ($\sigma = 0.585$) and journals ($\sigma = 0.228$) accept *H0*, that is, they are not influencers for the use of mobile applications. All the other means are important influencers for the use of mobile applications to generate communication between the city and the citizen. Thus, the use of a mobile application is an adequate mean to establish a communication between the city and the citizen, and H_B is accepted. Figure 11 illustrates how the means can be used to influence the acceptance of mobile applications as means of communication.

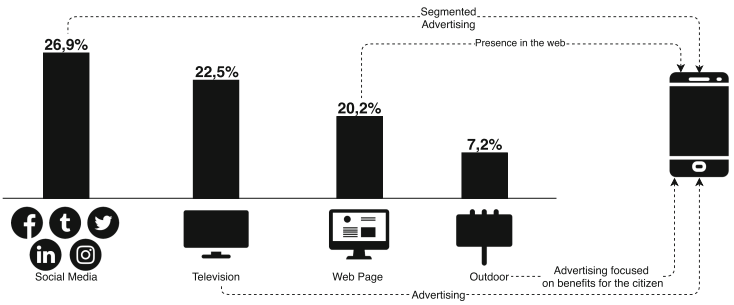


Fig. 11. Distribution of the means of communication as influencers to the use of mobile applications.

***H_C*: The Type of Information that the Citizen Seeks Depends on Several Characteristics, Such as Age, Profession, Means of travel, and the Region where he Lives:** The citizens' interest on specific information is segmented in several groups as age, gender, mean of transportation, and rural or urban. To determine if different groups of citizens have different interests, two types of tests were carried out: ANOVA and Qui-square for the following hypothesis: *H0*: The type of information citizens are interested is not related to the characteristics of the citizen, and *H1*: The type of information citizens are interested depends on the characteristics of the citizen. Results are presented in Table 2, and *H1* is accepted for most cases, indicating that the H_C research

question is accepted and the diverse types of information are conditioned by several characteristics of the citizen. Therefore, to reach citizens, targeted marketing approaches is of major importance, since they consume information in different ways.

Table 2. ANOVA and Qui-Square tests for H_C.

Activity	ANOVA			Qui-Square	
	σ				
	Age	Occupation	Mean transport	Gender	Rural/Urban
Study	0.012	<0.001	<0.001	0.423	0.171
Read news	<0.001	<0.001	0.073	0.003	0.002
Watch movies	<0.001	<0.001	0.174	0.844	<0.001
Social media	0.003	0.005	0.002	<0.001	0.003
Public transports	0.001	0.004	<0.001	0.008	0.017
Touristic points	0.375	0.008	0.014	0.838	0.068
Search for events	0.668	0.603	0.842	0.273	0.286
Usefull contacts	0.012	0.007	<0.001	0.047	0.199
Available services	0.102	0.158	0.011	0.321	0.008
Products	0.012	0.167	0.302	0.496	0.636
Collaborative tools	<0.001	<0.001	0.057	<0.001	0.008

4 Conclusions

This paper addresses the problem of citizen participation in SC. The methodology followed was based on two essential aspects: analyzing solutions implemented in other SC and understanding the citizen. In the latter, more than knowing what the city has to offer, it explored the citizen's opinion about what interests him, understanding the way he sees the city and whether it influences his participation. This work allowed us to realize that cities tend to take advantage of technology. Still, they do not always communicate correctly, as most citizens are not aware of the technology used in cities, affecting their participation.

When analyzing the research hypotheses, citizens have different interests according to their characteristics, such as age, gender, the location where they live, and means of transport used. Based on this, it was also studied that the type of information that captivates the citizen's interest the most is the information that influences their daily lives and rewards them for their attitudes. Then, based on the integrity of the research hypotheses, it is concluded that the digital medium that the citizen best receives is the mobile application, taking into account the means of communication used in the city as influencers of the application. Results show that the way the city communicates is of major importance

since, without communication, the citizen does not obtain information about the city. For example, when verifying that the mobile application is the best way received by the citizen, citizens must know about their existence to enjoy the application and participate in the city. Therefore, nevertheless a user-centered mobile application becomes an asset for citizen participation in the city, it is necessary to bear in mind that the stakeholders in a city need to communicate between them and with the citizen so that he becomes an active member of the city.

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