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Circular Economy for Cities and Sustainable Development: The Case of the Portuguese City of Leiria

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Abstract: The principles of the circular economy play a central role in the global economy, and its application is suggested in the context of business and urban development for creating cities capable of reinventing themselves in the long term. The main objective of this study is to assess the perception of the inhabitants of the city of Leiria (Portugal) regarding the concept of the circular economy and the acceptance of circular actions and projects, gathering their opinions and motivations, and understanding the challenges they perceive for implementing the circular economy. This study is relevant because, to date, no work has analyzed the circular practices of citizens and consequent projects for a city. The adopted methodology consisted of a mixed qualitative and quantitative approach, which was materialized in the administration of an online questionnaire to the inhabitants, workers, or students of the Municipality of Leiria. We obtained a sample of 547 answers. These results underwent statistical analysis, and it was concluded that the familiarization of study participants with the circular economy is low, but that they have a positive predisposition to engage in rental, reuse, article repair, and recycling activities. The municipality should continue to invest in the extension and promotion of circular economy initiatives in the city, since there is a predisposition of respondents towards using them, which may lead to the conclusion that they would support their implementation. This is an initial step that should promote further research into understanding the perception of citizens regarding circular economy initiatives and actions, followed by how it might be supported to achieve its full potential in cities.

Keywords: circular economy; Portugal; survey; sustainable cities; sustainable development goals; sustainable economy development

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1. Introduction

For several decades, the predominant economic model has focused heavily on the speed of growth, with little regard for the efficient use and management of available resources [1,2]. This led to the establishment of a linear economy (LE), where raw materials are extracted and then processed to produce products. These products remain in the economy, and their usefulness decreases over time until they are discarded at the end of their useful life. In this linear model, the production and consumption of new products directly leads to an increasing volume of waste, representing a highly inefficient use of the raw material. The circular economy (CE) model offers an alternative, based on principles different from the current linear economic model [1,3]. Rather than using natural resources and disposing of products when they are damaged or no longer needed, a CE maximizes the use of materials and preserves their value for as long as possible. A CE is based on the use of intelligent digital services and solutions and the design and production of products with greater durability, repairability, reusability, and recyclability. Garbage is considered to

be a valuable resource, and the sharing and rental of products are promoted as a result of their reuse/repair.

Many companies have adopted new methodologies/technologies/infrastructures to respond in a better way to the CE challenge [4]. However, the CE, in addition to being applied as an organizational vision (micro-level) can (and should) be applied at the level of cities. Cities are the fundamental cells of society. Given the concentration of resources, be they financial, natural, or human, in such territories, they are fertile environments "for implementing, demonstrating and replicating innovative circular solutions" [5].

Portugal is a good setting in which to study the implementation of CE policies, given the empirical evidence suggesting that the CE "in Portugal is in its early stages" [6]. The city of Leiria, although it has not entered the Top 20 ranking for environmental sustainability in Portuguese towns and cities [7], therefore has all conditions to constitute a circular city [8]. This municipality is located in the Central Region, integrating the sub-region of Pinhal Litoral. According to data from [8,9], there has been a growing improvement in the population's purchasing power, with good internal and external recognition due to urban and industrial dynamism, which is driven by the existence of companies with big national and international projection. Public transport types are varied, including buses, trains, and Mobilis (urban transport in Leiria). However, the car is the most widely used mode of transport, and there is a weakness in rail transport due to the decline of the western line.

According to [8,10], this municipality has been developing several circular projects, such as developing the scope of urbanism, community gardens, mobility, infrastructure, and security, and, finally, in the protection of public spaces. However, there is the possibility of exploring even more themes and, in this sense, there is a need to understand the perception and predisposition of residents, workers, and students in Leiria towards the CE arising from their daily lives. Despite the wealth of studies on the CE [5,11], few studies examine individuals' perspectives concerning the CE [12–20], with most of them focusing on consumers, and few examining how demographic characteristics (such as age and gender) are associated with perceptions of the CE. As far as we are aware, there are no studies examining citizens' perceptions of the CE and its implementation in cities. We believe that the successful implementation of CE principles is dependent upon citizens' awareness concerning the need for such implementation. We aim at contributing to the literature exploring individuals' perspectives on the CE by examining the perceptions of the CE and its implementation of Leiria city's citizens and the association of gender and age with such perceptions.

The main goal of this study is to assess the inhabitants' perception of the concept of the circular economy and their acceptance of circular actions and projects, gathering their opinions, motivations, and ideas regarding the challenges in implementing the circular economy in the Municipality of Leiria (Portugal). We also examined whether the responses to some questions that could be interpreted as representing a higher or lower environmental sensitivity are associated with sex and age.

The adopted methodology materialized in the administration of an online questionnaire to the inhabitants, workers, or students of the Municipality of Leiria, having obtained a sample of 547 responses. These results were also subjected to statistical analysis to examine the association of circular economy-related environmental sensitivity with gender and age. This was performed to assess whether these two demographic characteristics would offer a fruitful basis for eventual conscientization policies. Our findings suggest that such an association exists only in the case of sex, with women being more environmentally sensitive. The main findings regarding the acceptance of Leiria inhabitants to actions and circular projects lead us to conclude that their familiarization with the CE is scarce, but that they have a positive predisposition to adhere to the rental, reuse, and repair of articles, as well as recycling activities. The municipality should continue to invest in the extension and promotion of CE initiatives in the city since there is a predisposition of respondents towards them, which may lead to the conclusion that they would support their implementation.

Henceforth, the paper is divided into four sections. Section 2, the literature review, presents some important aspects that provide the theoretical framework for the empirical work to be developed, namely, concerning the concepts and background of the circular economy, the circular economy action plan, and circular cities. Section 3 addresses methodological issues, starting by detailing the data collection and then the sample selection. Section 4 presents the results and discusses the findings and, finally, Section 5 summarizes the conclusions of the study.

2. Literature Review

One prominent definition of CE is the one proposed [21]: "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro-level (products, companies, consumers), meso level (eco-industrial parks) and macro-level (city, region, nation and beyond), to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations".

As contended by [5], given the "high concentration of resources, capital, data and talent over a small geographic territory", cities are fertile environments "for implementing, demonstrating and replicating innovative circular solutions". On the other hand, cities are "the main consumers of natural resources", as well as "the main producers of urban waste and polluting emissions originating in anthropogenic industrial sectors" [6]. According to [22], cities consume around 60 to 80% of global natural resources, produce around 50% of global waste, and are responsible for 75% of greenhouse gas (GHG) emissions. Ref. [23] suggest that CE business models and practices can help to achieve several of the SDG goals. We believe the same is the case with CE-based city management. Applying CE principles to urban development will create cities that are capable of reinventing themselves in the long term, bringing prosperity to their citizens [22,24,25]. Sustainable cities converge towards achieving the Sustainable Development Goals (SDG). Such management can contribute to SDG 11: making cities and communities inclusive, safe, resilient, and sustainable.

According to [26], there is currently no single definition of what constitutes a circular city. Ref. [25] define a circular city as a "city that practices CE principles to close resource loops, in partnership with the city's stakeholders (citizens, community, business and knowledge stakeholders), to realize its vision of a future-proof city". A city has several other dimensions and attributes that can be classified according to location, geographic proximity, urbanism, and specific cultures. It is also a complex system composed of its economy, infrastructures, networks, and resources, in which two different actors (who decides and who benefits) and stakeholders (business, public sector, knowledge institutes, citizens, and communities) are interconnected.

Currently, cities produce 50% of global waste, are responsible for 75% of GHG emissions, and consume about 60 to 80% of natural resources globally. The UN, also estimates that by 2050, 66% of the world's population will reside in cities, and that the global ecological footprint will triple by 2030 [27,28].

Thus, Ref. [22] suggests that to solve these problems, it would be useful to adopt a circular approach to resource management. Although loop actions are fundamental for the implementation of the circular flows of resources in cities, there are many challenges to their execution. In addition, cities are facing scarcities of resources, such as water, with a dependence on fossil fuels, which leads to an increase in their price.

Ref. [29] showed that the CE policy in cities attracts jobs, creates investment opportunities, and that most of these investments have been related to RE. It also states that support for regulatory and economic policy is very important in establishing new businesses and circular projects and can be linked to municipal CE strategies and goals, facilitating stakeholder collaboration in practice and the economic support needed to overcome certain financial barriers.

According to [3] municipal governments have a key role to play in building prosperous, livable, and resilient cities. By incorporating CE principles into urban policy levers, cities can bring about changes in the use and management of materials in cities; urban priorities around access to housing, mobility, and economic development can also be addressed in a way that supports prosperity, jobs, health, and communities. For [3] vision, involvement, urban management, economic incentives, and regulation are the five categories that make the interconnections between urban policy levers.

In view of the above, it is not a surprise that there is a wealth of literature on the topic of the CE in cities, as evidenced by recent studies offering panoramas of such literature [5,11,30,31]. In spite of such wealth, few studies examine individuals' perspectives concerning the CE and those that exist focus on consumers [12–20] As far as we are aware, there are no studies examining citizens' perceptions of the CE and its implementation in cities. As [32] put forward regarding the need for urgent measures regarding climate change mitigation, one potential solution lies in enhancing the commitment of citizens to "adopting voluntary more sustainable and low-carbon lifestyle alternatives". Even in the case of aspects that do not depend on citizens' behavior, such as the design of green infrastructures, it is "essential the appeal to the individual awareness of each citizen" [6].

In a recent study on barriers to the CE in the European Union, Ref. [33] revealed the lack of consumer interest and awareness as one of the main barriers. Although there is a lack of research focusing on countries' citizens or cities' inhabitants, it is not too farfetched to suggest that citizens/inhabitants' lack of interest and awareness is the main barrier to the success of a country/city's implementation of CE strategies.

It is crucial to acknowledge the importance of a city's inhabitants' CE behavior as a factor in the successful adoption of a CE strategy. Individuals' CE behavior "consists of more than consumption; it is multidimensional as it moves from orientation to disposal and needs, such as greater awareness and involvement when choosing products from more sustainable sources, buying, sharing, participating, recycling, and other activities to avoid waste" [19]. It is thus important to address a city's inhabitants' perspectives regarding the CE. Studies examining the association between certain socio-demographic characteristics and perceptions concerning the CE are also scarce [12,15]. Both [16] examining the case of Tianjin, China, and [12], examining the case of Saudi Arabia, found limited awareness regarding the CE and a positive association between the respondents' level of awareness and their level of education, as well as a positive association between their age and their inclination towards resource conservation and pro-environmentalism. Based on a questionnaire survey conducted with consumers from China, Indonesia, Singapore, Thailand, and Vietnam, Ref. [15] found that younger people who are well educated are less resistant to sharing platforms, although many respondents revealed concerns regarding the inconvenience of sharing, which led these researchers to conclude that the youth market could be penetrated if companies were able to address these barriers. They also found, in contrast, that middle-aged respondents were more aware of the benefits of purchasing recycled and remanufactured products, and this led these authors to suggest that "with the right messages and marketing strategies, this group may be the easiest to convert their interests into actual purchase".

Our preoccupation is not with what companies can achieve, but rather with how political decision makers at the city level can increase citizens' awareness regarding CE opportunities by targeting diverse groups differently. Hence, we will also examine the associations between perceptions concerning the CE and sex and age.

3. Data and Methodology

3.1. Data Collection

To achieve the objective of measuring the perception of the inhabitants of the municipality of Leiria (Portugal) regarding the concept of the circular economy, and their acceptance of circular actions and projects, their motivations, and the challenges they

perceive in implementing the circular economy, an online questionnaire was developed and applied.

After writing the questionnaire, a pre-test was given to 10 adults, aged between 18 and 52 years. This aimed to assess the clarity and sequence of the questionnaire and to understand if it was too long. After the pre-test, some changes were made in terms of a reformulation of the questions, sequence, extension, and adequacy of the language used.

The questionnaire could be filled out through an online platform, "Google Forms", and was available from 1 July 2020 to 7 August 2020. It was disseminated via social networks (Facebook®, Linkedin®, Instagram®) and shared in specific interest groups, such as residences, parishes, sports groups, groups of local associations, among others, to have a greater reach and to attract responses. The collection of responses carried out in this way was a matter of convenience, as the fact that their dissemination was carried out through social networks meant that only those who had access to them could answer the questionnaire.

On the other hand, it suffered the "snowball effect". Refs. [34,35] suggest that this is a non-probabilistic method, capable of recruiting participants at low or no cost and from a large geographic area in which individuals selected to be studied invite new participants from their network of friends and acquaintances.

The questionnaire included questions about the demographic characterization and questions related to the perceptions of the CE and its initiatives. Thus, the sociodemographic characterization section contained 3 dichotomous questions and 4 single-answer questions. Regarding the section on the perceptions of the CE and its initiatives, it contained 15 Likert-scale questions, 4 dichotomous questions, 4 multiple-choice questions, and 1 open-answer question. The questionnaire is available upon request from the authors. It has been partially adapted from the [36,37] questionnaires. However, new themes were explored to obtain results and conclusions aimed at the objective of this study.

3.2. Sample Selection

For sample selection, the following inclusion criteria were considered: (a) resident in Leiria. In case point (a) was not verified, the following criteria were considered: (b) work or study in Leiria. Out of a total of 569 responses to the online questionnaire, 22 responses were excluded. The final sample included 547 responses, as shown in Figure 1.

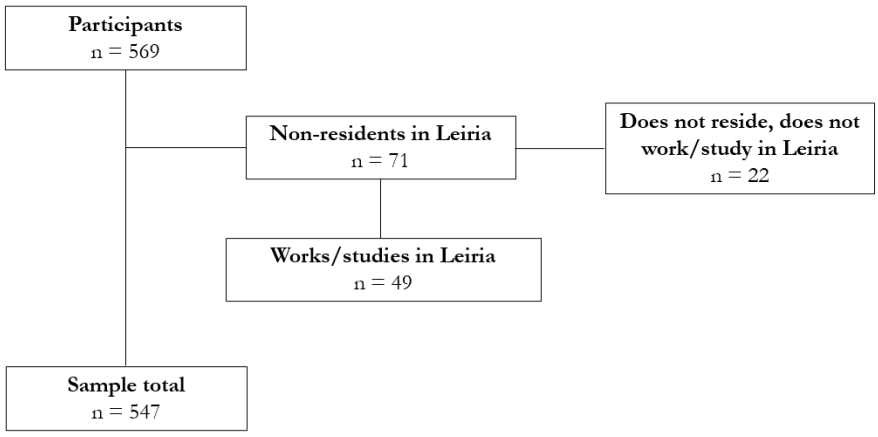

Figure 1. Selection of the convenience sample. Data were analyzed in IBM® SPSS® Statistics version 26.0 for Windows®. Descriptive analysis was performed, as presented in the next point referring to the sociodemographic characteristics of the participants.

3.3. Statistical Analysis

3.3.1. Hypotheses

We also examined whether the responses to some questions that could be interpreted as representing a higher or lower environmental sensitivity are associated with sex and age.

According to [38] "sex differences do matter", men and women are indeed different, both at home and at work. Despite often being attributed to men and women having different learned psychologies and environmental experiences, "recent advances in neuroscience, however, have brought to light important neurological distinctions" (p. 771). Literature is abundant on citizens' environmental behavior, providing evidence that "women in Western societies are more likely than men to hold pro-environmental attitudes and act accordingly" [39]. A recent example is [32], who found that women "exhibited a higher level of extra mitigation habits" (p. 23).

Hypotheses 1 (H1). *The levels of environmental sensitivity of the female respondents are higher compared to their male counterparts.*

Slightly different from the case of sex, the literature on age and environmental sustainability suggests the existence of negligible relationships between the two, with older individuals appearing to be more likely to have pro-environmental behaviors, both in non-work settings [40] and in work contexts [41]. Ref. [32] found evidence that women "exhibited a higher level of extra mitigation habits" (p. 23). Refs. [12,16] found a positive association between age and resource-conservative and pro-environmental behavior.

Hypotheses 2 (H2). *The levels of environmental sensitivity are positively associated with age.*

3.3.2. Variables

Respondents' demographic characteristics considered in the statistical analysis were the following:

- Sex: a dichotomous variable assuming the values 0 for men and 1 for women;
- Age: categorical variable, with six age categories: 18–30; 31–43; 44–56; 57–69; 70 or over.

3.3.3. Statistical Methods

To test the hypotheses presented above, we have used the chi-square contingency analysis.

4. Results and Discussion

4.1. Descriptive Profile of the Respondents

Regarding the characterization of the sample of 547 responses, the majority live in Leiria, Pousos, Barreira, and Cortes (32.4%) (Figure 2). Female responses are predominant (65.3%). Regarding age, there is a predominance of responses from ages between 18 and 30 years (57.0%), followed by ages between 44 and 56 years (21.8%).

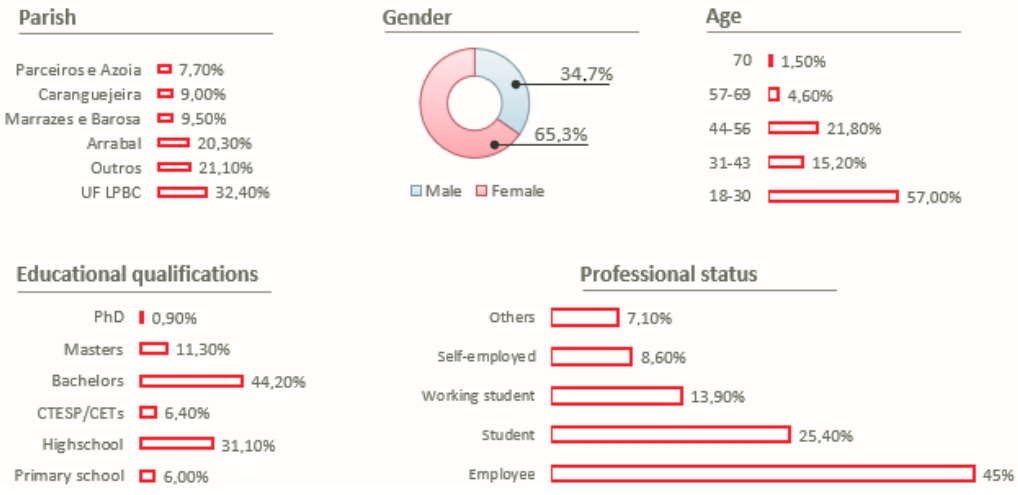

Figure 2. Sociodemographic characterization of the sample. Regarding professional status, most participants were employees (45.0%). Concerning educational qualifications, most participants (44.2%) went through higher education (Bachelor/postgraduate).

4.2. Main Results and Discussion

The main findings are summarized in Table 1.

Table 1. Summarized findings.

Question	Answer	Percentage
1. Before this questionnaire, were you already familiar with CE?	Unfamiliar	56.5%
	Familiar	43.5%
2. What is your opinion regarding the following activities? * (Only the most selected option is displayed)	Answer	Percentage
Rent products to third parties	Open to the concept	37.1%
Rent products from third parties	Open to the concept	35.1%
Second-hand purchases	Open to the concept	34.6%
Recycling	Positive	69.3%
Repair of articles	Positive	58%
Second-hand sales	Positive	44.6%
3. When you have a broken product/device usually choose: (Results obtained depending on the individual choices of respondents and respective final sum. Only the most selected option is displayed)	Buy a new one	35.6%
	Use it for another purpose	20.70%
	Fix it	72.4%
	Donate it to someone or an institution	11.7%
4. What obstacles do you find when you want to repair an item? (Results obtained depending on the individual choices of respondents and respective final sum. Only the most selected option is displayed)	The repair price does not offset the purchase/convenience of a new item	49.3%
	Brand/establishment does not offer repair service	24.6%
	I don't know where I can repair my articles	17.3%
5. Are you aware of the two community gardens (spaces used for gardening and horticultural production open to the entire community) in the Municipality of Leiria?	Yes	37.7%
	No	62.3%
6. What initiatives to promote the CE do you consider to be of interest to implement/expand in Leiria? ** (Only the most selected option is displayed)	Answer	Percentage
6.1 Creating more community gardens	Makes some sense	38%
6.2 Creation of a community repair center that repairs objects so that, instead of being thrown away, they are reused or converted into new products	It makes perfect sense	52.2%
6.3 Creation of a web page with information about circular practices and sharing of success stories, aimed at consumers and companies	It makes perfect sense	53.2%
6.4 Development of a mobile application that allows you to order food surpluses at reduced prices, combating food waste	It makes perfect sense	60%
6.5 Implementation of support for the development of circular businesses	It makes perfect sense	51.9%
6.6 Implement a network for sharing bikes and extending bicycle paths	It makes perfect sense	50.3%
6.7 Installation of green roofs/roofs (vegetation on a structure/building)	Makes some sense	34.9%
6.8 Public investment in abandoned/underutilized buildings to optimize their use	It makes perfect sense	62%
7. In which areas do you think the application of the CE can benefit the city? (Results obtained depending on the individual choices of respondents and respective final sum. We only present responses with >50% of cases)	Food waste	70.9%
	Waste management	60.4%
	Reduction, reuse, repair, and responsible consumption	63.4%
	Renewable energy and energy efficiency	57.3%
	Ecological public purchases	51.6%
	Mobility/transport	50.5%

* Original survey allowed respondents to answer the question where: 1—Negative; 2—Not open to the concept; 3—Neutral; 4—Open to the concept, 5—Positive. ** Original survey allowed respondents to answer the question: 1—It doesn't make sense; 2—It makes little sense; 3—Neutral opinion; 4—Makes some sense; 5—It makes perfect sense.

The majority of the respondents (56.5%) are unfamiliar with the concept of the CE. These results are consistent with [33] finding that a lack of interest and awareness concerning the CE is one of the main barriers to its development.

A total of 37.1%, 35.1%, and 34.6% of the participants would be "Open to the concept" regarding "Rent products to third parties", "Rent products from third parties", and "Second-hand purchases", respectively. These results are consistent with a recent [37] which found that 90% of respondents had no experience in renting second-hand products. One reason for this low involvement in CE practices can be due to the lack of sufficiently developed markets for them. In this sense, the [37] elaborates upon several suggestions for future policy action: one of the recommendations is to increase consumer awareness about the rental and second-hand purchase markets. The study found that consumers are generally willing to adopt CE practices, but that their actual involvement may be insufficient due to a lack of knowledge of how to buy second-hand products and how to rent them. Recently, there has been an increase in the number of CE initiatives and awareness-raising campaigns/platforms in the EU. Thus, awareness should be raised about the benefits of buying second-hand and rental products to reach a greater number of consumers.

Only 44.6% of respondents also have a positive opinion regarding "Second-hand sales". According to [42], this concept has been gaining popularity, both nationally, such as in the OLX®, Facebook Marketplace®, and CustoJusto® platforms, and worldwide, such as in the Amazon® platform, which offers its consumers the option to buy new versus used products, and the eBay® platform, which is the most popular place for second-hand online sales. In our study, the results indicate that women are more prone to engaging in second-hand sales than men (63.9% vs. 36.1%). Similarly, in the [43], women were more prone to selling items for reuse (70% vs. 63%).

Respondents have a positive opinion about "Recycling" (69.3%). This result is consistent with those of [44], in which it was concluded that around 84% of respondents have a recycling habit. In the study from [43], 61% of Portuguese respondents, when questioned about "which action you think would make the biggest difference in the efficiency with which we use resources", opted for the action "recycle garbage at home". In both of the aforementioned studies, participants believe that there should be more information on how and where recycling can be carried out so that more people can recycle: 66% in [43] and 20.5% in the [44]. Additionally, 60% of Portuguese in the [43] mention that it would be important to implement tariffs for those who do not recycle and, consequently, 35.9% of participants in the [44] emphasize that incentives should be offered in the delivery of waste. This is consistent with recycling being, "at least in the industrialized west", "fairly well organized and widely accepted, and sustained across different social groups" [18]. We also found that women are more prone to recycle than men (women, 66.5% vs. men, 33.5%), which is consistent with the hypothesis put forward in the previous section and with the findings of [45].

Approximately 58.0% of the participants have a positive opinion regarding the "Repair of articles". At the same time, 72.4% chose this option when asked about what they do when they have a broken product/appliance, and 55.2% consider that "it makes perfect sense" to create a community repair center. In the above-mentioned [37], 64% of respondents said that they repair their products when they break. According to [46], the repair of products is essential to maintain their functionality and delay, or avoid, their rejection. Ref. [24] states that increasing product longevity is one of the central considerations in CE thinking. Ref. [47] states that whenever a product is successfully repaired, the attachment to it gains strength. This way, product durability should play a key role in a sustainable circular economy, and it should improve the efficiency of material flows in standard conceptions. This is thus an encouraging finding.

Related to the repair issue, we found that 27.8% of men vs. 72.2% of women believe that "it makes perfect sense" to create a community repair center that repairs objects so that, instead of being thrown away, they are reused or converted into new products. Additionally, related to this issue, when asked about what obstacles they encounter when they want

to repair an item, the most selected option was "The price of repair does not offset for the purchase/convenience of a new item" (49.3% of responses). In [43], in most countries, participants claim that the price of a repaired product is not advantageous compared to the purchase of a new product, with the percentage obtained from Portugal reaching 32%.

Moreover, 62.3% of the respondents were not aware of the two community gardens in the Municipality of Leiria. According to [48], community gardens do not have a widely recognized common definition. However, we can find community gardens or forms of collective urban agriculture all over the world. Most of these gardens have an economic function (providing food) and a social function (establishing social contact), regardless of the geographic region in which they are located. Similar to the results obtained in the present study, Ref. [49] gave a questionnaire in the surrounding area of nine community gardens in Paris, France, and most participants (63%) were not familiar with its existence and 80% would not be interested in participating in this concept. Interestingly, of the 28.0% of participants who answered that they would be interested in joining a community garden in the municipality of Leiria, 68.8% stated that this was due to their desire to produce food for consumption. Ref. [50] report that more and more people are looking for fresh, local, organic products. Although individuals seeking these foods are still a minority, these trends show that there is a growing appreciation of food in society. Community gardens respond to this interest: they provide the people involved with fresh local produce, usually produced without chemicals, and bring food cultivation closer to the urban resident.

A total of 38.0% of the participants considered that the creation of more community gardens in Leiria would make some sense as an initiative to promote the CE, and there was a significant relationship between age and predisposition towards the creation of more community gardens. Regarding the predisposition of participants in the 18 to 30 age group, 50.0% considered that "it makes perfect sense" to create more community gardens.

A total of 34.9% considered that the installation of green roofs makes some sense as an initiative to promote the CE. Ref. [51] emphasize that the implementation of green roofs (which can be installed in new or pre-existing buildings) brings numerous benefits to the CE in the city, constituting an efficient solution for water retention, thermal insulation, protection, and the increased lifespan of waterproofing, as well as facilitating the capture of CO_2, the production of oxygen, and the incorporation of recycled materials. In addition, they improve the urban landscape and real estate valuation. Ref. [51] analyzed 143 policies to encourage the implementation of green infrastructure in 113 cities around the world, found that most of them are concentrated in Europe and North America.

Approximately 51.9% of respondents said that the "Implementation of support for the development of circular businesses" makes perfect sense. In a study carried out in Leiria, Ref. [52] entitled "Barriers to the implementation of the Circular Economy in companies in the Region of Leiria", using a questionnaire, the obstacles to the implementation of the CE that companies in the Region of Leiria faced were identified. The three main barriers identified were: (1) the lack of cooperation and collaboration between companies, emphasizing the need for greater dynamization and information on industrial symbiosis processes; (2) companies consider that their customers are not concerned with issues related to the environment, emphasizing the role of information and awareness not only for policymakers, but also for companies; (3) the lack of subsidies or tax benefits for investing in circular productive systems, emphasizing the creation of tax rebate systems for them or a greater dissemination of success stories. The latter is in line with the results of the present study.

Additionally, 50.3% of the participants considered that it makes perfect sense to "Implement a network for sharing bikes and extending bicycle paths" while, when asked "In which areas do you consider that the application of the Circular Economy can benefit the city?", 50.5% of cases responded "Mobility/transport". According to [53], the bicycle-sharing network is a relatively new form of transport in urban areas and has become increasingly popular in cities around the world in recent years. Refs. [54,55] further add that this is a system in which the ownership of the bicycle is held by the supplier, who sells

the bicycle's functions through modified distribution and payment systems. According to [56,57], this network is associated with several social, environmental, and economic benefits, including a decrease in CO_2 emissions, the reduction of various diseases (for example, diabetes and obesity), and a decline in traffic congestion and noise pollution through the provision of alternatives to vehicular transport and an increase in the use of public transport.

Approximately 62.0% believe that it makes perfect sense to have "public investment in abandoned/underutilized buildings to optimize their use". According to [58], the topic of urban regeneration and building reuse is in line with SDG 11 ("Make cities inclusive, safe, resilient and sustainable"). In some countries, abandoned buildings are already being used to optimize their use. Ref. [59] describe that, in Duiven, Netherlands, an existing cluster of buildings was reused as a 24,000 m^2 headquarters for the energy network company Liander, providing more than 1500 jobs. Here, over 80% of the raw materials from the original structures have been reused, and the newly added structures have been designed so that they will be fully rebuilt in the future.

Furthermore, 51.9% of respondents believe that it makes perfect sense to develop a mobile application that allows ordering surplus food at reduced prices, combating food waste, as an initiative to promote the CE, while the most selected option for the question "Where areas do you think the Circular Economy can benefit the city?" was "Food Waste", with 70.9% of respondents choosing this option. According to [60], the concept of food waste is not well understood by the common citizen, as it is an ambiguous concept that confuses the effective ways to solve the problem. However, food waste can be defined as "any food originally intended for human consumption that is discarded due to degradation and/or expiration resulting from insufficient knowledge and/or action be "the consumer".

Ref. [60] gave an online questionnaire to 100 participants in the United Kingdom to understand the perception of consumers regarding food waste. They found that the majority of the respondents (96%) believe that there is an unnecessary excess of food waste. Additionally, most respondents (85%) identified that they were likely to avoid wasting food if they were given more information about the importance of this topic and the subsequent benefits of carrying out sustainable eating practices. Incorporating sustainable food waste management into the educational system was an intervention identified by participants as having the potential to lead to sustainable practices being carried out at home.

"Reduction, reuse, repair, and responsible consumption", with 63.4% of responses, was also one of the areas identified by the participants in which they believe that the application of the CE can benefit the city of Leiria. According to [61], reduction requires the development of responsible consumption culture, while reuse focuses on the activity of existing institutions and the verification of opportunistic growth and, finally, recycling requires action from deadlocked institutions to prevent the spread of regulatory conflict in global governance structures.

Sharma [62] highlights that circular economy strategies should be integrated into the stimulus of the fiscal proposal for economic recovery, as the current drift is centered on "planned" obsolescence", which means to deliberately design "products with flaws, technical limitations, and incompatibilities to promote new replacement within a few years of purchase". Therefore, the focus of premium business models should be to confront this corporate unsustainability strategy to make technically durable products with high recyclability. Furthermore, this article recommends the creation of a labeling system that shows the durability of a device, so that the consumer has the choice between an inexpensive product and an expensive durable product.

When asked "In which areas do you consider that the application of the Circular Economy can benefit the city?", 60.4% of cases identified the topic "Waste management". According to [63], transforming waste into energy can be the key to a CE, allowing the value of products, materials, and resources to be kept for as long as possible in the market, minimizing waste and the use of resources. As creating a CE is at the top of the EU agenda,

all EU member states must move away from antiquated waste disposal towards smarter waste treatment by understanding the CE approach in their waste policies.

"Renewable energies and energy efficiency" (57.3% of responses) were also one of the areas that participants identified that the application of the circular economy can benefit the city. Ref. [64] developed a study that presents the results of questionnaires applied in Portugal to 3646 participants to assess public opinion on four RE technologies, namely, water, wind, biomass, and solar. The results of this study demonstrate a very positive attitude towards RE in Portugal, even in regions where these plants are already operating. "Ecological public purchases (purchase of goods and services that integrate technical environmental requirements)" were other areas that participants identified that the application of a CE can benefit the city, with 51.6% of respondents choosing this.

4.3. Test of Hypotheses

We report results regarding the cases in which the assumptions of the chi-square test are not violated. We found no association between:

- Sex and second-hand sales (p-value = 0.251 > α = 0.05);
- Sex and recycling (p-value = 0.070 > α = 0.05);

We found a positive relationship between:

- Sex and community repair centers (p-value = 0.003 < α = 0.05);
- Sex and second-hand purchases (p-value = 0.012 < α = 0.05);

We found a negative relationship between:

- Age and second-hand purchases (p-value $\approx$ 0.000 < α = 0.05);
- Age and community gardens (p-value = 0.002 < α = 0.05)

There is some evidence that women and younger citizens are more environmentally sensitive. The finding of the association between sex and recycling is not entirely consistent with [45]. Having a positive association between sex and recycling significant only at the 0.1 level may be related to the fact of recycling being, "at least in the industrialized west", "fairly well organized and widely accepted, and sustained across different social groups" [18], p. 356. Regarding age, contrary to other studies [32,45], we found that younger citizens seem to be more environmentally sensitive. This may be related to "young people being those most concerned about climate change" [32], and with the media attention that climate change and youth activism regarding this issue has received in the past few years.

5. Conclusions

In general, it can be concluded that the familiarization of residents, workers, or students in Leiria with the CE is scarce. We also verified that participants have a positive predisposition to engage in rental, reuse, article repair, and recycling activities. It seems as though there exists some level of association between such predispositions and age and sex. The municipality must continue to invest in the extension and promotion of community gardens, publicizing their benefits, promoting local food production, and contributing to more sustainable and resilient urban communities.

Respondents agree with the suggestion that future initiatives should be developed in Leiria within the scope of the CE, and it can be concluded that they would support their implementation. The most supported initiatives were the "Public investment in abandoned/underutilized buildings to optimize their use" and the "Development of a mobile application that allows ordering surplus food at reduced prices, combating food waste". This latter initiative identified is consistent with the "Food Waste" area, which obtained the highest percentage of favorable responses from the participants.

This article has limitations. Ref. [65] points out that the fact of having used an online questionnaire implies access to the internet, which, in turn, leads to a bias in the sample by requiring digital literacy skills from the participants. In addition, the questionnaire was only online for a month, and it was given only to residents, students, or workers in the municipality of Leiria, meaning that we are dealing with a convenience sample,

as this group does not represent the total population. Another limitation is the fact that companies/institutions linked to CE practice were not considered, causing certain CE actions in Leiria to have been excluded. As suggestions for future studies, similar surveys to various stakeholders, including companies, as well as in other cities, should be carried out. One of the contributions of this study pertains to its focus on the perception of citizens regarding circular economy initiatives and actions. We agree with the idea that "to mitigate climate change and also to pave the way to a circular economy, the role of citizens is fundamental and a shift in personal behavior is required", as put forward by [32], p. 3. Although viewing people as consumers is also crucial, we believe that research should refocus towards approaching people as citizens. We think this study contributes to such refocusing.

From a practical contributions point of view, the results of this study contribute particularly to the CE literature by exposing flaws and good prospects in the understanding of how the role of the CE can impact the consumer and the city's future. For example, given the support of citizens regarding "Public investment in abandoned/underutilized buildings to optimize their use" and the "Development of a mobile application that allows ordering surplus food at reduced prices, combating food waste", political decision makers in Leiria are well advised to consider producing policies in this regard. Another important finding from a practical contributions point of view is that women and younger citizens seem to be more prone to have a positive predisposition. Political decision makers in Leiria are well advised to design strategies of conscientization for the circular economy with different characteristics for younger and older people and women and men. For example, decision makers in Leiria may want to create awareness about the CE among male and older citizens.

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