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Published in:
Sustainability (Switzerland)

DOI (link to publication from Publisher):
10.3390/su15010680

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

sustainability

MDPI

Article

How Can We Measure the Prioritization of Strategies for Transitioning to a Circular Economy at Macro Level? A New Approach

Patricia Guarnieri [1,*], Lucio Camara e Silva [2], Fazli Haleem [3], Augusto Bianchini [4], Jessica Rossi [4], Brian Vejrum Wæhrens [5], Sami Farooq [6], Edgar Reyes, Jr. [1,†], André Luiz Nascimento Reis [7] and Barbara de Oliveira Vieira [8]

1 Faculty of Economics, Business, Accounting and Public Policies, University of Brasília—UnB, Brasilia 70910-900, Brazil
2 Department of Production Engineering, Federal University of Pernambuco, Caruaru 55014-900, Brazil
3 Department of Management Sciences, Shaheed Benazir Bhutto University Sheringal, Sheringal 18000, Pakistan
4 Department of Industrial Engineering DIN, University of Bologna, 40126 Bologna, Italy
5 Center for Industrial Production, Department of Materials and Production, The Faculty of Engineering and Science, Aalborg University, 9220 Aalborg Øst, Denmark
6 School of Management Sciences, Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Swabi 23640, Pakistan
7 Superintendent at Brazilian Post Office, Brasília 70002-900, Brazil
8 Faculty of Economy, Business Administration and Accounting, Department of Management, University of Brasília—UnB, Brasilia 70910-900, Brazil
* Correspondence: pguarnieri@unb.br
† In memorian.

Abstract: This paper aims to develop and validate a questionnaire to measure the prioritization of strategies to transitioning towards a circular economy and to compare different countries. We proposed a questionnaire based on a five-level ordinal scale to evaluate the 24 strategies of the circular economy under a set of ten criteria given technical issues, as well as social, environmental and economic dimensions of sustainability. Each strategy was defined and evaluated by the participants on the same scale, who are stakeholders involved in the transition towards a circular economy. The validation was conducted by two main procedures, including semantic validation through 17 experts from five countries and statistical validation by 347 survey respondents from 25 countries. The results show that the questionnaire seems a reliable and valid tool to analyze which circular economy strategies countries, regions and cities prioritize. Few studies have been conducted to validate instruments about the circular economy; they are focused at the micro level, (industry). Studies that validate measurement instruments regarding the circular economy at the macro level are lacking. This study is the first one to validate the circular economy instrument at the macro level. It can help researchers and practitioners from public and private sectors from a variety of organizations in proposing actions to enable the transition and create performance indicators.

Keywords: circular economy; strategies; sustainability; transition; validation of an instrument

Citation: Guarnieri, P.; e Silva, L.C.; Haleem, F.; Bianchini, A.; Rossi, J.; Wæhrens, B.V.; Farooq, S.; Reyes, E., Jr.; Reis, A.L.N.; Vieira, B.d.O. How Can We Measure the Prioritization of Strategies for Transitioning to a Circular Economy at Macro Level? A New Approach. *Sustainability* **2023**, *15*, 680. https://doi.org/10.3390/su15010680

Academic Editor: Alessandra Neri

Received: 25 October 2022
Revised: 19 December 2022
Accepted: 21 December 2022
Published: 30 December 2022

1. Introduction

The traditional "take, make, use and dispose" model, originated and encouraged by the Industrial Revolution, is environmentally incompatible with today's reality, since it depends on the availability of a large amount of natural resources [1]. A sustainable future requires a system that balances social, environmental, and economic development [2].

In this context, the circular economy (CE) concept emerges, opposing the traditional economy's paradigm, by proposing a behavioral change in how people consume, use natural resources, and treat waste as a result of production and integrated chains adaptability [3]. In comparison to the linear economy, Korhonem et al. [4] argued that the CE model

consists of an economic model based on a societal view of production and consumption, maximizing the service produced, and bringing an approach that transform the linear consumption and production pattern. The circular economy impels a more intelligent management of its non-renewable resources to prolong their existence [5,6].

The CE transition can be analyzed at three levels to achieve sustainable development (environmental quality, economic prosperity and social equity): (i) macro: global, regional; (ii) meso: eco-industrial parks; and (iii) micro: company, product [7].

Several studies on the topic have been published in recent years, given the growing interest and strategic importance of circular economy research and its application. However, as Korhonen et al. [8] pointed out, the majority of these studies lack consolidated theories and methods. In general, there is paucity of research regarding validation of questionnaires to measure CE initiatives. Few studies address this issue. The literature review highlights a lack of measurement scales at the macro level to support the transition towards a circular economy at the country's level. A few studies approach measuring the circular economy, and there is no standardized metrics of measuring CE according to De Pascale et al. [9]. De Pascale et al. [9] analyzed 61 indicators measuring the circular economy through a literature review and categorized in micro, meso, and macro levels, which are based on the 3R core CE principles. However, the study did not approach how to incorporate the indicators at the macro level to prioritize strategies enabling the transition towards CE. A general concept of the research relies on a very popular proverb in management and applied economics: "what gets measured gets done". Without measuring, we cannot manage any system. It is believed that the right set of measurements underpin further policy development and a common understanding on priorities for the circular economy development. By providing a consistent scale for measurement, there appear to be new opportunities for countries to examine procedures/strategies to achieve what is set out to perform. So, the novelty of this study is related to constructing and validating a scale to prioritize the strategies adopted at the macro level of transition towards a circular economy, considering the environmental, social, economic, and technical issues.

For instance, Nuñez-Cacho et al. [10] developed a scale based on circular economy concepts for the building industry to measure the relevance of the adoption and implementation of circular economy initiatives for companies. More recently, Kuzma and Sehnem [11] developed a measurement scale for circular economy business models based on the principles of innovation and structural model validation. In their study, the authors pre-validated the research instrument to develop and validate the final scale. In addition, Mishra et al. [12] developed and validated an instrument based on inductive and deductive approaches to assess barriers to adopting circular economy practices in micro, small, and medium enterprises (MSMEs).

Scientific research regarding the circular economy mainly originated in the business community in the last decade, leading to the concept of the circular economy being in vogue. Thus, it remains very superficial and requires critical analysis [8].

At the macro level, the circular economy is already being discussed by managers from public and private organizations, researchers and legislators in countries such as China, Japan, the United States of America and the European Union as part of the need for changes in the production and consumption patterns, aimed at environmental protection and resources for future generations [13,14]. Cramer [15] conducted a comparative study of the governance of the circular economy (CE) in sixteen different countries considering the transition management literature and network governance.

One of the biggest challenges for circular economy researchers is to find a reliable scale/questionnaire to measure CE strategies towards the CE transition. Given the earlier mentioned discussion, to the best of our knowledge, only a few studies have been conducted to validate research instruments concerning the circular economy focused on industries. However, there is a paucity of validated questionnaires that can assess strategies at the meso and macro levels. Thus, considering the lack of validated questionnaires to measure the prioritization of strategies aimed at the transition towards a circular economy at the

macro level, which can be applied to compare different countries, this paper aims to fill this research gap. A crucial question is how to measure the CE strategies at the macro level. Given this, we posit the following research questions:

RQ1—How to validate a scale to prioritize the strategies considering multiple criteria related to social, environmental, economic, and technical issues in a systematized way?

The objective of this paper is to develop and validate a questionnaire, which includes 24 strategies that enable the transition towards a circular economy at the macro level, evaluated by ten criteria based on the dimensions of sustainability (social, environmental, economic) and technical issues. Most CE studies published in recent years are based on non-validated data collection instruments, which introduce errors in the data and consequently in the results. Three errors are linked to a survey: errors related to the researcher, the instrument, and the respondent. This paper aims to reduce instrument-related measurement errors, which can occur even when an instrument is well-designed and planned [16], by validating the questionnaire instrument regarding CE strategies towards CE transition.

Both the strategies and criteria were gathered from sustainability and circular economy literature. Then, we proposed a questionnaire to evaluate the 24 strategies aimed at transitioning to a circular economy against a set of 10 criteria based on technical issues as well as social, environmental and economic. Each technique was defined by the participants, who then assessed it using the same scale. The validation was conducted by two main procedures: semantic validation through experts from five countries and statistic validation by 347 respondents from 25 countries. The questionnaire is available in the following languages: Brazilian Portuguese, English, Italian, and Spanish. We decided to translate the questionnaire into these four languages, considering that English is the most used in a scientific context; however, as we have in the research project, researchers from Italy, Brazil and Spain, it would be good to translate into more languages to increase the accessibility and understanding.

The results showed the main characteristics of respondents and the detailed process of the development and validation of the questionnaire. The findings show the reliability and validity of the questionnaire, thus confirming the validation of the questionnaire. This study contributes to the field of research on macro-level efforts to transition to a circular economy by proposing operational measurements that were tested using a robust approach with participants from several countries. As it is impossible to define a sample of the stakeholders interested in the circular economy transition, considering a cross-country approach, we widely disseminated this study in social media and the networks of the researchers participating in this project. The most used social media was LinkedIn, ResearchGate, Instagram, Facebook, Whatsapp, and also by e-mail. Clearly, we received more responses from the countries the researchers are located in, namely Brazil, Italy, Pakistan, and Denmark. This research instrument could be used as a diagnostic tool to assess, measure and monitor which circular economy strategies are prioritized at the macro level, i.e., by countries, regions, and cities. It can assist researchers and practitioners from public and private spheres to understand and propose actions and policies to facilitate the transition to a circular economy. Finally, the instrument can help them to develop performance indicators from the factors.

This paper is organized as follows. Section 2 presents a theoretical background on the circular economy and the transition to a circular economy. Section 3 shows the technical procedures to validate the questionnaire. Section 4 demonstrates the results. Section 5 concludes the paper.

2. Theoretical Background

2.1. Circular Economy Definition

The conceptual origins of the circular economy are linked to different areas of knowledge, mainly to ecological and environmental economics and industrial ecology [17]. Although the roots of its conceptualization originated in Europe, most of its initial de-

velopment took place in China, after the implementation of legislation on the subject [18]. Some studies have addressed the circular economy's origin [2,3,19]. Although there is no consensus on the origin, Korhonen et al. [8] claimed that two primary concepts, including cradle to cradle and industrial ecology, have led to it.

A broad concept of the circular economy, based on the World Commission on Environment and Development, covering the three pillars of sustainability, was proposed by Korhonen et al. [4] (pp. 38–39):

> "Circular economy is an economy built from social production-consumption systems that maximize service produced from the linear flow of nature, society, and energy flow. This is done using flows of cyclic materials, renewable energy sources, and cascade-type energy flows. The successful circular economy contributes to all three dimensions of sustainable development. Circular economy limits the flow of production to a level that nature tolerates and uses ecosystem cycles in economic cycles, respecting their natural reproduction rates."

Murray et al. [2] defined the circular economy as an economic model in which the planning, use and acquisition of resources and their production and processing are designed and managed to maximize ecosystem functioning and human well-being.

Geissdoerfer et al. [18] pointed out that the circular economy represents a regenerative system in which the inflow of resources and the waste, emission and leakage of energy is minimized by decelerating, closing, and narrowing the flow of material and energy.

2.2. Macro-Level Initiatives Regarding Circular Economy

Various countries and regions are developing policies and taking initiatives regarding the transition to a circular economy. In countries such as China, Japan, the United States of America and the European Union, the circular economy is already part of discussions by managers from public and private organizations, researchers and legislators related to the need for changes in production and consumption patterns, aimed at environmental protection and resources for future generations [13,14].

The European Commission launched the Green Deal in 2015, updating it in 2019 and enacting a related law in 2020, which has set the roadmap for a transformative change, including strategies to the transition towards a circular economy. The 27 member states have pledged to make the EU the first climate-neutral continent by 2050. In June 2021, the European Climate Law entered into force to enshrine the objective of climate neutrality by 2050 in a binding act [20–22].

In contrast to the developed countries, practices and policies related to waste management are still in their infancy stage in developing countries. In many [23–26], there are some decentralized discussions and initiatives but no institutional and centralized directives. In February 2022, the Circular Economy Coalition for Latin America and the Caribbean was launched, meeting the interests and initiatives on the circular economy promoted by the public and private sector, research institutes and universities and other social actors, as well as by the multiple initiatives of regional and international organizations. The primary purpose of this coalition is to create a shared regional vision and perspective with an integrated and holistic approach based on life cycle thinking. The scope of the work is driven by plastics, cities and construction, electronics, food and agriculture, industrial symbiosis and tourism [27].

The Chinese law on the promotion of the circular economy (CE) was the first to deal with the circular economy, establishing those industrial policies formulated by the State, that must comply with the requirements for the development of CE. The circular economy is recognized as an essential economic and social development strategy in China [28].

Meanwhile, the European action plan called "Closing the Loop—An Action Plan for the Circular Economy" only took place in 2015, focusing on eco-design, waste management as a secondary market, collaborative consumption models and product innovation, among others [20–22]. According to Zhu et al. [29], the initiative from China was a broader response to the environmental challenges created by rapid growth and industrialization, which

generates an increasing pollution level. It is possible to observe, according to McDowall et al. [30], that the European policies are framed in both economic and environmental terms, focusing on the potential for resource efficiency to increase competitiveness, while the Chinese policies are framed to control pollution and negative environmental impacts caused by the intensive industrialization process in the country.

2.3. Transition towards a CE, CE Barriers and Stakeholders

The CE transition can be analyzed at three levels, which aim to achieve sustainable development: (i) macro: global, regional; (ii) meso eco-industrial parks, industrial symbiosis; and (iii) micro: company, product [7,31,32]. In general, several countries' sustainable development action plans have yet to include advancements that allow them to transition from a linear to a circular economy model [33]. In Section 3, Table 1 summarizes various strategies based on literature that could enable the transition at the macro level via legal guidelines, action plans and public policies.

There are many hurdles which prevent the transition towards a circular economy. For instance, Ritzén and Sandström [34] identified many barriers to the circular economy transition. These drivers are usually related to one another because they reveal multi-dimensional and multi-domain elements, demonstrating the complexity of CE and what is necessary for its transition. The leading barriers identified by the authors are: (i) financial (measurement of financial benefits of the circular economy, financial profitability); (ii) structural (lack of exchange of information, unclear distribution of responsibilities); (iii) operational (infrastructure management/supply chain/reverse logistics); (iv) attitudinal (sustainability perception, risk aversion) and (v) technological (product design/integration in production processes).

Cramer [15] developed a model to analyze the effectiveness of CE governance and another one presenting four main avenues for developing CE in different socio-cultural and political contexts. The author used the Netherlands as the reference case, considering their expertise and tradition in network governance related to the circular economy. The study compared the government policies and practices regarding CE, categorizing their level of development. The study confirmed its hypothesis that public solid governance, the active involvement of relevant actors and receptivity to network governance are conditional to implementing CE effectively. However, some barriers and bottlenecks, besides a deep analysis, should be considered.

Neves and Marques [35] analyzed the transition from a linear to a circular economy, evaluating the role of economic, social, and environmental factors of CE. The authors found that the age distribution of a country is a significant predictor of a circular economy. In addition, they found that older people tend to be reluctant to change their behavior, while young people are more inclined to change the patterns of the linear economy. Thus, policies driven to older people are required. Another finding is related to the increase in per capita income. When it occurs, the propensity to accept products containing recycled materials decreases. On the other hand, income inequality makes moving toward a circular economy more difficult.

Jensen et al. [36] categorized 14 barriers into five categories (managerial, market, financial, technical and regulatory) when they investigated the contextual dependencies related to the barriers during the transition. According to the authors, barriers can differ in importance even by time horizon, and government power is a driving force when analyzing dependency.

Several stakeholders are involved in the transition toward a circular economy. In this context, it can highlight government, managers from various industry sectors, non-governmental organizations, associations of vulnerable workers, citizens, consumers, universities, research centers, consultancies and others. However, the stakeholders have conflicting viewpoints and interests to be considered. In this sense, various stakeholders' involvement plays a crucial role in the transition towards CE. For example, Asgari and Asgari [37] stated that while companies recognize the importance of transition, operational

risks cannot be calculated. Thus, some obstacles make the transition difficult, like the financial ones, concerning the measurement of financial benefits, lack of information and risk aversion.

Therefore, some recent studies show that the early stages of transition face a number of barriers [38]. Different barriers can be expected at different levels of maturity in the process of transition, and in the context of each stakeholder involved, the barriers can be different. The main hurdles to the transformation concentrating on business models are intellectual and operational [37].

According to van Langen et al. [38], policymakers perceive the transition as a socio-economic opportunity, whereas economists and scholars see it as an environmental opportunity. In this sense, it appears that stakeholders should be included in discussions on the strategies to be implemented by public policymakers to expose and effectively resolve operational and practical obstacles of transition.

Concerning Federal Entities that formulate public policies, Christensen [39] identified that municipalities could play a vital role in gathering and organizing the stakeholders in this transition: an essential agent of change to support and facilitate CE transformation. As indicated by Trần et al. [40], policymakers should assess individuals' participation in CE, paying attention to different groups. Because as the authors demonstrate, the attitude towards the decision has a significant impact on the purchase of CE products.

The transition towards a CE demands methods to monitor and evaluate the performance of the strategies implemented [41]. These methods should consider: (i) the resource consumption and regeneration by nature; (ii) more effective materials use; (iii) market costs and investments; (iv) environmental and societal services; (v) cradle-to-grave process parameters and (vi) direct and indirect labor [42].

2.4. New Institutional Theory (NTI) and Its CE Implications

This study uses the New Institutional Theory to analyze the results. The Institutional Theory was selected to confirm or refute the assumption that by generating a more favorable environment at the macro level, it would be possible to enable the adoption of strategies related to the circular economy at the meso and micro level [7,31,32].

According to the New Institutional Theory (NTI), organizations are embedded in social and political environments, which can impel them to assume similar practices, such as the transition towards implementing a circular economy (CE). These practices are often reflections or responses to rules, beliefs and conventions incorporated into the broader environment [43]. A central concept at NTI is an isomorphism, which deals with the process of influencing the environment in the organization [44].

From the perspective of the new institutionalism, institutions are created in situations where there are pressures from the institutional environment for the homogenization of organizations within an organizational field [44]. Isomorphism, specifically institutional isomorphism, is the notion that best represents the process of organizational homogenization and is a valuable tool for understanding the politics and ceremonies that permeate a considerable part of modern organizational life [44]. These authors identified three mechanisms through which institutional isomorphic changes occur: coercive, mimetic and normative isomorphism.

Coercive isomorphism occurs due to formal and informal pressures exerted on organizations by other organizations on whom they depend, and by the cultural expectations of the society in which organizations operate. These pressures can be felt as coercion, as persuasion or an invitation to come together in collusion, and the change can be a direct response to government orders [44]. Normative isomorphic mechanisms, in turn, are mainly derived from professionalization. Some important sources of normative isomorphisms are (a) the support of formal education and legitimation on a cognitive basis produced by university specialists; (b) the growth and establishment of professional networks that permeate organizations and through which new models are quickly disseminated; and (c) the selection of personnel. These processes drive the homogenization of organizations [44].

As for mimetic isomorphism, it occurs when organizations tend to take as a model in their field other organizations perceived as more legitimate or successful. It is worth pointing out that the models can be disseminated involuntarily, indirectly through the transfer or rotation of employees, or explicitly by organizations such as consulting firms or industry trade associations [44].

Finally, the search for legitimacy is crucial in adapting to institutional pressures. Organizations seeking legitimacy and social acceptance attempt to confirm their actions, structures and practices to socially acceptable standards [45]. However, in some situations, organizational responses to institutional pressures show a dissociation of formal policies from the daily practices of the organization's internal technical core [46]. According to these authors, this dissociation between politics and organizational practices is called decoupling.

2.5. Intermediate Summary: Findings Relevant to the Study and Questionnaire Design

The circular economy represents an industrial system given to reuse and regeneration at conceptual, organizational, and operational levels. However, there is a need to consider the lack of indicators about circularity, which is one of the most critical challenges for the future of CE. For instance, only eight studies focused on an evaluation model are cited in Lewandowski's study [47] and none considered a scale for measuring CE. Other studies, like those by Lihong and Hui [48] or Shen and Qi [49], are more general; for example, the center of the measurement on energy or emission levels, the sustainability index [50] or sustainability building assessment [51], whereas Silvestre et al. [52] concentrated on particular elements, like supply chain management or materials. From this point of view, there is a lack of knowledge about what type of indicators of CE could be used [53,54]. In their literature review some indicators were gathered at the micro, meso, and macro levels [9]. However, they did not indicate how to deal with the variables. The indicators can show how the variables' values compare to a predetermined reference point [52].

CE scale development has not been extensively studied. For the building industry, Nunez-Cacho et al. [10] created a scale based on circular economy concepts to assess the value of adopting and implementing circular economy initiatives for businesses. A measurement scale for circular economic business models was recently created by Kuzma and Sehnem [11] based on the concepts of innovation and structural model validation. In their study, the authors pre-validated the research instrument to develop and validate the final scale. Furthermore, Mishra et al. [12] created and validated a tool based on inductive and deductive methodologies to evaluate obstacles to implementing circular economy practices in micro, small, and medium-sized businesses (MSMEs). Given this, overall, few studies address the scale development regarding CE. Among these studies that address scale development regarding CE are those at the micro level. There is a paucity of research concerning scale development on CE at the macro level, which is one of the significant hurdles to the transition towards CE. A very important question in this context, which needs to be answered is how to measure the application of CE principles at the macro level. This study addresses the development of scale measurement at the macro level and fills the research gap.

3. Materials and Methods

3.1. The Development of the Questionnaire

The questionnaire was divided into three main sections: (i) introduction and consent statement; (ii) evaluation of strategies using an ordinal scale based on a series of statements (criteria); and (iii) sample characteristics. To allow for broader involvement, the questionnaire is provided in four languages to facilitate the participation of stakeholders: Brazilian Portuguese, English, Italian, and Spanish. As mentioned before, the first questionnaire was elaborated in English, which is the most used in the scientific context. Nevertheless, considering the participation of researchers from Italy, Brazil, and Spain, we decided also to translate into more languages to increase the accessibility and understanding for native people speaking Italian, Spanish, and Portuguese.

The first section of the questionnaire is an introduction that explains the purpose of the study, which is to analyze the strategies related to the circular economy and to evaluate how these strategies are prioritized for the transition from a linear towards a circular economy, at the level of countries/regions/cities (macro-level). The questionnaire focuses on obtaining perceptions of people interested or in charge of positions involving the wide range of sustainability and circular economy issues. For this purpose, we selected 24 strategies to enable the transition from specialized literature and documents gathered from the leading countries implementing the circular economy. Thus, actions, plans and legislation from the European Union and its members, North American, Asian, and Latin American countries, were considered (Table 1). Considering that we based Table 1 on documents and papers related to countries and regions, all 24 strategies mentioned can be classified as being strategies in the "macro level" in the context of the transition towards a circular economy.

In this part, we also explained that the purpose is to analyze the perception of respondents related to the future adoption of these strategies because it is supposed that by generating a more favorable environment at the macro level, it is possible to enable the adoption of strategies related to the circular economy at the meso and micro level (cities, organizations). In addition, we emphasized that the results from this research can aid decision-makers involved in the policymaking related to a circular economy. The results can be used to evaluate which strategies should be prioritized in public policies to facilitate the transition towards a circular economy based on the opinions of many stakeholders.

We also included in this introductory section the information related to the protection of individuals regarding processing personal data. We assured that the information provided would be processed only for scientific research purposes and in an aggregate way, thus guaranteeing complete anonymity. Finally, we included a consent statement in which the respondents could agree or disagree to participate.

The second part was composed of 24 strategies (Table 1) to transition to a circular economy. Each respondent was asked to evaluate these 24 strategies based on a series of ten assertions that served as the criteria (Table 2) organized in a "Likert type" ordinal scale. The original Likert scale ranged from 1 (totally disagree) to 5 (totally agree), with the middle point as a neutral position. The evaluation aims to get the respondents' perception based on an ordinal scale with five levels, ranging from level 1 (very low) to 5 (very high). In this scale, the middle corresponds to the 3 (medium level) and not a neutral position.

It is essential to point out that the survey of 24 strategies (Table 1) and 10 criteria (Table 2) was based on an integrative literature review, following the protocol of Cronin, Ryan and Coughlan [55]. The steps used to select and filter the materials are:

(1) The problem question was: What are the leading strategies and criteria, at the macro-level, used in the context of the transition towards a circular economy?
(2) Inclusion and exclusion criteria, the material considered for this purpose were documents from governments, the European Union, representative organizations of sectors, legislations, plans of action and roadmaps of different countries found through Google Scholar. As keywords, we used "circular economy" AND strategies OR actions OR initiatives AND transition. The research was conducted considering the documents published until February 2020. Thus, legislation and documents published after this period was not considered. The language considered was Portuguese, English, Italian and Spanish, considering the level of knowledge of researchers involved in this study. The documents not adherent to these criteria were eliminated.
(3) The analysis was made following the procedures of Bardin [56], related to categorical content analysis, which has three main steps: (i) pre-analysis; (ii) exploration of the material; and (iii) treatment of results, inference and interpretation.

Posteriorly to analyze the content, the results can be categorized, which is, according to Bardin [56], an operation to classify elements that constitute a set by differentiation and subsequently, by grouping according to analogy with the previously defined criteria that allows a group of elements to be brought together (registration units) through common characteristics of a generic name. The categorization was conducted a priori,

enabling the floating reading of the selected materials. The results were categorized into strategies/actions/initiatives (Table 1), their descriptions and sources and the main criteria (social, environmental, economic and technical) and their respective sources (Table 2). The third section aimed to characterize the questionnaire respondents, asking them to indicate their country of residence, level of knowledge related to the circular economy, segment of acting and type of organization and position.

Table 1 depicts the main strategies that facilitate the transition to the circular economy gathered from the literature and documental analysis.

Table 2 shows the main criteria gathered from literature used to evaluate strategies and plans for sustainable strategies.

Table 1. Strategies to induce transition at the macro level.

Nr	Actions/Strategies	Description	Source
1	Inter-firm collaboration	Arrange collaboration and business relations. Rules are needed because interdependencies are increased and become more specific as compared to collaboration in linear systems.	[57–60].
2	Waste management Directives	Provides a general framework of waste management requirements and sets the basic waste management definitions, define actors, responsibilities, rules, guidelines, principles, instruments and other relevant information.	[10,20–22,61–66].
3	Reverse Logistics	"Process of moving goods from their typical final destination for the purpose of recapturing value, or proper disposal" [67] (p. 2).	[61,68].
4	Closed loop (Reuse, Repair, Reconditioning, Remanufacturing, Recycling)	Reusing goods means extending the utilization period of goods through the design of long-life goods; introducing service loops to extend an existing product's life, including reuse of the product itself, repair, reconditioning and technical upgrading, and a combination of these. The result of the reuse of goods is a slowdown of the flow of materials from production to recycling [69]. The operational steps of take back can be cited: transportation, disassembly, reconditioning, reintegration and the financial aspects [70].	[20–22,68,70–75].
5	Sectorial Agreements	Sectorial agreements are acts of a contractual nature, signed between the Government and the value chains (manufacturers, importers, distributors or traders), aiming at the implementation of shared responsibility for the products' life cycle. Its main objective is to guarantee the competitiveness of an economic sector in order to reduce the values and the benefits sharing [61].	[20–22,57,61,65].
6	Social inclusion	Social inclusion is the act of including in society categories of people historically excluded from the socialization process, considering their race, color, sex, language, religion, political or other opinion. As well as those in situations of socioeconomic vulnerability, such as homeless people, immigrants and low-income people [76].	[21,22,61,66,75].
7	Financial incentives and/or Support and Fiscal measures	Financial incentives can be considered monetary rewards to promote the take-back and recycling activities, in general, aimed to consumers. Financial support refers to grants, subsidies, direct and indirect investments, and public–private partnerships through which city governments can enable city development towards a circular economy. The funds may draw on existing budgets and revenues or be raised in addition and specifically to support the circular economy initiatives. Fiscal measures such as taxes, penalties and charges, can help incentivize or discourage behaviors [77].	[22,57,59,77–79].
8	Stakeholders involvement	Stakeholder engagement is often key to the development of effective circular economy roadmaps and policy strategies [77].	[20–22,61,65,66,72,75,77].
9	Industrial symbiosis	A process-orientated solution, concerned with using residual outputs from one process as feedstock for another process, which benefits from geographical proximity of businesses [74].	[20–22,27,66,74].
10	Partnerhips with research and Industry	Partnerships can help build capacity for innovation and the scaling of circular economy practices with the aim of expanding access to a variety of contributors who otherwise risk being excluded from the innovation process [66,77].	[22,60,66].
11	Circular economy roadmap	Roadmaps can provide overarching direction by setting strategic goals, can set a direction and inform the development of other policies, standards or material and waste classifications and regulations [77].	[77].

Table 1. *Cont.*

Nr	Actions/Strategies	Description	Source
12	Eco-cities	Livable, resilient cities that are regenerative by design. Byembedding circular economy principles into urban policy levers, cities can bring about changes to the use and management of materials in cities; and urban priorities around access to housing, mobility and economic development can also be met in a way that supports prosperity, jobs, health and communities. Changes to material choices, uses and management can also open up local production opportunities [77].	[27,80].
13	Incentives to SMEs	Small and medium-sized enterprises (SMEs) and entrepreneurship are essential drivers of economic and social well-being. Representing 99% of all businesses, generating about 60% of employment and totaling between 50% and 60% of value added in the OECD area, SMEs are key for delivering sustainable and inclusive economic growth [66]. Examples: Incentives for SMEs to hire or buy expertise through mentor networks; Financial assistance programme for SMEs; Cross-industry SME market development programme; Expanding assistance to SME exporters and facilitating contacts between SMEs and overseas buyers; Online and physical desks for helping SMEs; Special lines of credits to SMEs; Calls of public Procurement aimed to SMEs; Incubator Programme; Reduction of taxes rate, etc. [66].	[22,60,66].
14	Product Policy	Widen the Ecodesign Directive beyond energy-related products so as to make the Ecodesign framework applicable to the broadest possible range of products and make it deliver on circularity.	[22].
15	Green or Sustainable Procurement	The inclusion of circular economy principles and requirements in the Green Procurement and/or Sustainable procurement, mainly in public context.	[22,60,77].
16	Regulation	Legislation and regulation are a core domain of government and can play an important role in shaping markets, influencing behavior and removing barriers that inhibit progress [77]. Regulations can influence the transition from linear to circular for a specific material or end of life product [75].	[22,75,77].
17	Getting value out of biomass	Biomass refers to the mass of living organisms, including plants, animals and microorganisms, or, from a biochemical perspective, cellulose, lignin, sugars, fats and proteins. Biomass includes both the above- and below-ground tissues of plants, for example, leaves, twigs, branches, boles, as well as roots of trees and rhizomes of grasses. Biomass has been used as a fuel source [81].	[21,22,27].
18	Construction and demolition (C&D) waste	Proper management of C&D waste and recycled materials—including the correct handling of hazardous waste—can have major benefits in terms of sustainability and the quality of life [22].	[10,21,22,27,77].
19	Water reuse	The potential role of treated wastewater reuse as an alternative source of water supply is now well acknowledged and embedded within international, European and national strategies. UN Sustainable Development Goal on Water (SDG 6) specifically targets a substantial increase in recycling and safe reuse globally by 2030 [22].	[10,22,73,77].
20	Energy efficiency	Energy efficiency simply means using less energy to perform the same task—that is, eliminating energy waste. Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports and lowering our costs on a household and economy-wide level [82].	[10,22,73,77].

Table 1. *Cont.*

Nr	Actions/Strategies	Description	Source
21	Reduction of food waste	Preventing and reducing food waste, from those who produce and process foods (farmers, food manufacturers and processors) to those who make foods available for consumption (hospitality sector, retailers) and ultimately consumers themselves [28].	[20–22,27,72,77].
22	Eco-innovation and eco-design	Eco-innovation is regarded as a key factor in the shifting from a linear to a CE. Eco-design is considered as a catalyst to switch from linear economy to a circular economy. Products are required to be designed both for circular loops and for revenue generation [74].	[22,66,71,74,75,77,83,84].
23	Creation/Generation of Jobs	Potential to generate Jobs at the local level aiming the social-productive inclusion of citizens.	[20–22,61,65,85,86].
24	Sharing economy	Providing the capability or services to satisfy user needs without needing to own physical product [74].	[65,74,77].

Source: Research data.

Table 2. The main criteria used to assess strategies and plans for circular economy strategies.

Category		Criterion	Description	Direction	Source
Social	C1	Adaptability to current legislation.	The degree to which the circular economy strategy helps to comply with regional and national regulations.	Maximize	[87,88].
	C2	Social acceptance	The degree to which the alternative helps to increase public acceptance of circular economy strategies.	Maximize	
	C3	Jobs creation	The absorption potential of the regional/national workforce according to the requirements that will be created by the application of the strategy.	Maximize	
Environmental	C4	Reduction of incorrect disposal of waste	The degree to which this alternative increases the number waste collected and prevents it from being disposed of incorrectly.	Maximize	[87–91].
	C5	Prevention of the environment	Reduction of negative impact to the environment (reduction of the use of water, energy, pollution, reduction of fossil fuels, reduction of the use of landfills).	Maximize	
Economic	C6	Investment cost	The total amount of cost incurred to implement the strategy.	Minimize	[87,88,91].
	C7	Operational and Maintenance Cost	The cost incurred to maintain this strategy operational and to guarantee its maintenance.	Minimize	
Technical	C8	Technical difficulty	Difficulty level to implement a given action due to the knowledge, technologies and solutions required	Minimize	[17,87]
	C9	Adaptability to local conditions	Degree to which this alternative can be applied without obstacles, based on the particular characteristics of the region/country.	Maximize	
	C10	Functionality	Degree to which this option has the potential to remain constant and smooth, such as, having the maintenance requirements for specialized personnel and, simplicity of operation.	Maximize	

Source: Research data.

The criteria in Table 2 are divided into four categories: Social, environmental, economic and technical and were used to evaluate each one of the 24 strategies involved in the transition to a circular economy on an ordinal scale ranging from 1 (lowest level) to 5 (highest level).

Table 3 shows a sample of the type of questions of the questionnaire. Each of the 24 strategies was evaluated using the same scale, which consisted of a set of ten criteria, divided into four categories: social, environmental, economic and technical criteria.

Table 3. Sample of questions and scale of the questionnaire.

REVERSE LOGISTICS: Logistics operationalization of the return of goods from their typical final destination with the purpose of recapturing value or carrying out the proper disposal. Uses the logistics infrastructure, involving the activities of transport, warehouse, storage, purchasing handling of goods, information system and others. It can be performed "in-house" or by outsourcing it, through third-party reverse logistics providers. This strategy:	
Complies with regional and national regulations.	1. Very Low 2. Low 3. Medium 4. High 5. Very High
Helps to increase public acceptance of the circular economy.	
Enhances the absorption of the regional workforce.	
Prevents incorrect waste disposal.	
Contributes to the preservation of the environment.	
Has a cost for implementation.	
Has a cost to maintain in operation.	
Has a difficulty to implement, due to the knowledge, technologies and solutions required.	
Has obstacles/barriers, based on the particular regional characteristics.	
Has the potential to remain constant, considering mainly maintenance requirements for specialized personnel and simplicity of operations.	

Source: Research data.

An additional section of the questionnaire with seven questions was used to characterize the sample of the participants of the study for the statistical validation, including their continents and countries of origin, acting segments and sectors, the size of their businesses, if they worked directly with CE and their level of circular economy understanding. The questionnaire was prepared on the Google Forms platform. The following section presents the results related to the characterization of the study participants.

3.2. Validation of the Questionnaire

The instrument went through a validation process after it was developed, with the goal of increasing its level of reliability, improving understandings of the assertions and eliminating any inaccuracies. This process took place in two steps: semantic validation and statistical validation.

Two types of validation were used in this study: content validation and construct validation. Content validation is conducted through the judgment of the researcher or experts regarding the content of the instrument, which was done through the semantic validation by experts. Construct validity seeks to assess whether the scale is actually measuring what it purports to measure. It can be achieved through statistical techniques, as this research proposes [92]. Thus, the purpose to conduct the survey with stakeholders in this paper is aimed just to validate the questionnaire and not to analyze the prioritization of strategies under the social, environmental, and economic criteria.

For this purpose, we conducted an exploratory factor analysis, Cronbach's alpha coefficient, the Kaiser–Meyer–Olkin (KMO) index and the Bartlett sphericity test [93]. Following that, confirmatory factor analysis (CFA) is used to confirm the structures of the priori identified factors related to the strategies to induce the transition to the circular

economy. The CFA aimed to verify the adequacy of the measurement of the constructs (strategies) through the variables used in the questionnaire.

It is important to emphasize that the results chosen in the next sections is not derived from the application of the questionnaire to analyze the prioritization of the strategies under the set of criteria. The application will be conducted in further studies. The results are related to the process of validation of the questionnaire, to minimize the measurement errors related to the instrument. In Section 4.2, the sample of respondents were characterized in order to demonstrate the detail of the participants of the study and to point out some limitations of our data collection.

4. Results: Validation of the Questionnaire

The instrument went through a validation process after it was developed, with the goal of increasing its level of reliability, improving understandings of the assertions and eliminating any inaccuracies. This process took place in two steps, semantic validation and statistical validation.

4.1. Semantic Validation

Given that the questionnaire was written in four languages: Portuguese (Brazilian), English, Italian and Spanish, all of which contained the same contents and assertions, semantic validation including face and content validation was performed. The process of semantic validation was conducted by a total of 17 experts including nine from Brazil, three from Italy, one from Spain, two from Argentina and three from the United Kingdom.

To ensure coherence, objectivity, clarity, and readability, semantic validation is required prior to implementation. If the instrument is unclear, inconsistent and confusing, the assertions can be misunderstood, consequently, the analysis may be impaired.

The main aspects pointed out by experts were: (i) the need to clarify the audience in the introduction of the questionnaire; (ii) the need of standardized terms; (iii) the need to remove the existence of typos punctuation errors; (iv) the need to conduct some semantic adjustments (in terms or words) and to rephrase/readjust sentences; (v) the need to include examples in some assertions related to strategies; (vi) the need to move the characterization section to the end of the questionnaire; (vii) the need to include segments and sectors in the characterization of the respondents' section; (viii) the allowance to choose more than one sector option in the characterization of respondents section; (ix) the improvement of the layout. The updated questionnaire versions in all four languages completely include these suggestions in order to line up with its main purpose.

The experts also criticized the size of the questionnaire and the number of assertions; however, we are unable to change this specific aspect, because the 24 strategies aimed at transitioning to a circular economy were derived from a literature survey (Table 1). We recognize that excluding a strategy from consideration would be arbitrary. Concerning the assertions, we kept all of them, because they are based on the ten criteria that were selected through a literature review (Table 2). Since we plan to use a multicriteria decision aid (MCDA) method to evaluate the alternatives (strategies) versus criteria (assertions) in the future, the assertions (criteria) must be the same for all the 24 strategies to enable the MCDA analysis.

4.2. Characterization of the Sample of Respondents

The questionnaire was disseminated widely online through a link in the months of September 2020 to February 2021 to statistically validate it. We received 347 responses from 25 countries, resulting in a diverse profile in terms of origin, segments and sectors of acting and level of knowledge. The following results present the main characteristics of the participants of this study. Figure 1 shows the countries of origin of the participants of this study.

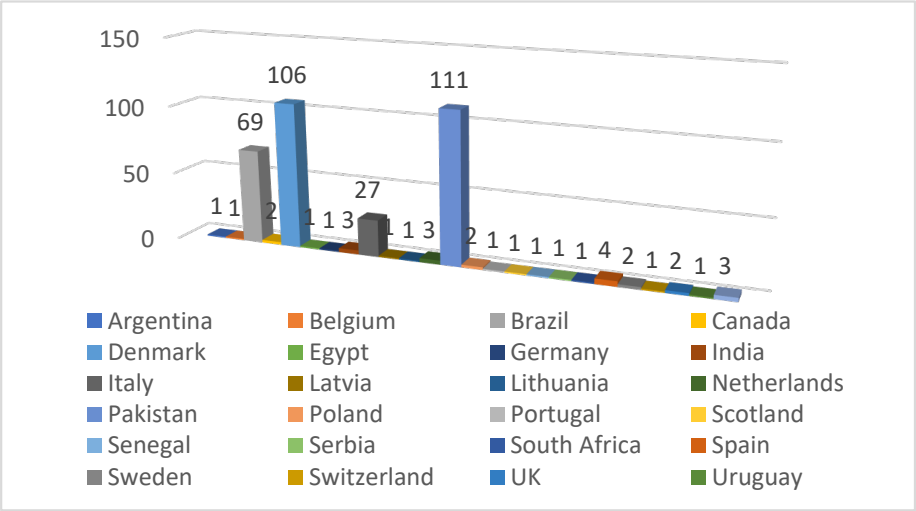


Figure 1. Countries of participants of the study. Source: Research data.

Four countries can be detached as the main participants of this study: Pakistan with 111 responses; Denmark with 106 responses; Brazil with 69 responses and Italy with 27 responses. The other countries had a lower degree of participation in the survey. However, we decided to keep the single-unit responses to illustrate that to obtain more reliable results, we need an effective participation of the other countries with less participation. Then, it is important to highlight that this validation cannot be generalized to all countries participating in the study, which is recognized as a limitation. The participants were divided into continents in Figure 2. These results can be explained due to the location of the researchers of this study, which resulted in a broader network.

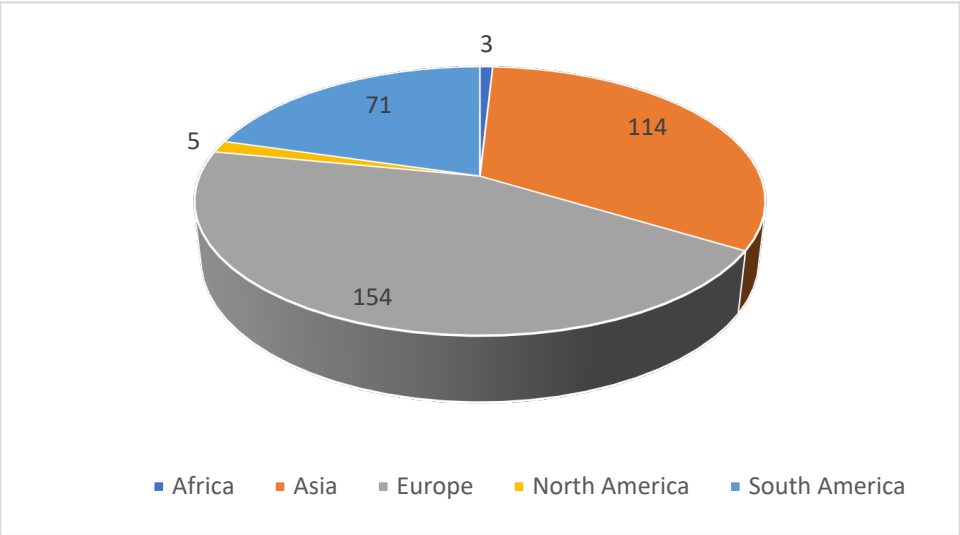


Figure 2. Continents of the participants of the study. Source: Research data.

Figure 2 shows that we obtained three participants from Africa; 114 from Asia, 154 from Europe, five from North America and 71 from South America. Figure 3 shows the profile of the participants by segments of acting.

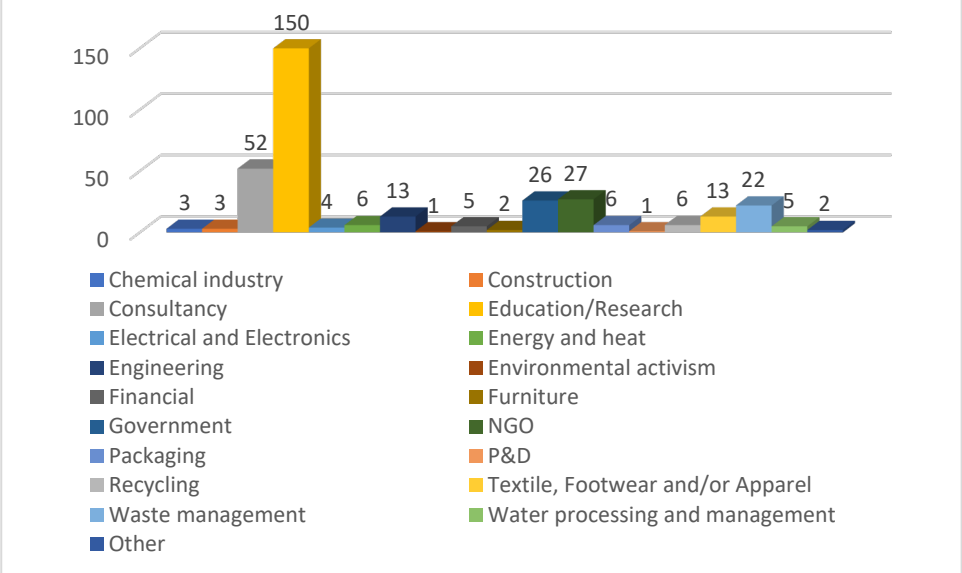
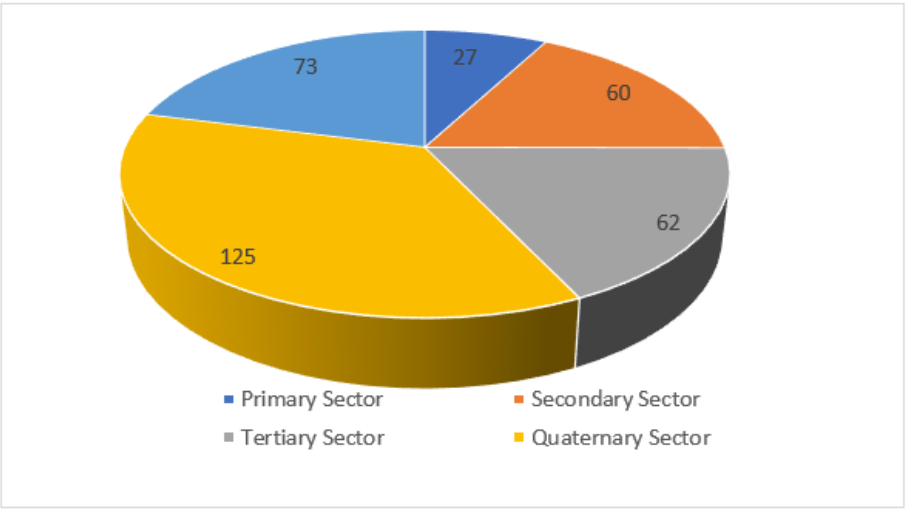


Figure 3. Segments of acting of the participants of the study. Source: Research data.

The most prominent sectors were education/research, with 150 responses; the consultancy with 52 responses, followed by non-governmental organizations (NGO), with 27 responses; government with 26 responses; waste management with 22 responses; and engineering with 13 responses, with the remaining sectors receiving six or less responses each. We asked about the business sectors in which the participants operate. Figure 4 illustrates the participants' business sectors.



Sectors	Description
Primary Sector	involves the extraction and/or production of raw materials.
Secondary Sector	involves the transformation of raw materials into goods.
Tertiary Sector	involves trade and providing services to consumers and /or companies).
Quaternary Sector	involves intellectual activities, such as information generation and sharing.
Quinary Sector	involves non-profit services such as health, education, culture, research (unpaid), police, firefighters, civil guard and non-governmental organizations.

Figure 4. Sectors of acting of participants of the study. Source: Research data.

Figure 4 shows that the primary sector received 27 responses, the secondary sector 60 responses, the tertiary sector 62 responses, with the quaternary sector receiving 125 responses, followed by the quinary sector with 73 responses. The primary sector had the lowest degree of participation. Figure 5 shows the size of the enterprises of participants.

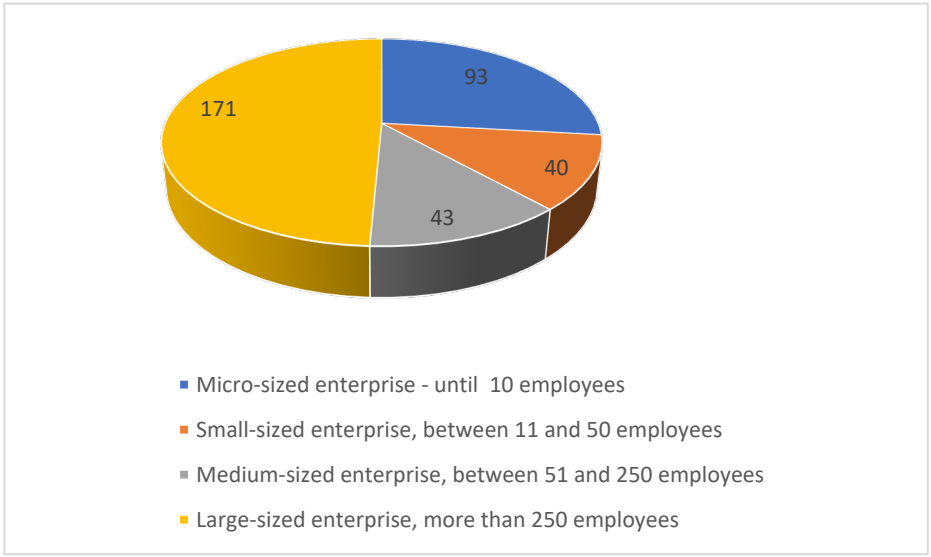


Figure 5. Size of enterprises of participants of the study. Source: Research data.

Large-sized enterprises received 171 responses, followed by the micro-sized enterprises with 93 responses, the medium-sized enterprise with 43 and the small-sized with 40 responses. We also asked the participants whether or not the participants work directly with the circular economy (CE). The results are presented in Figure 6.

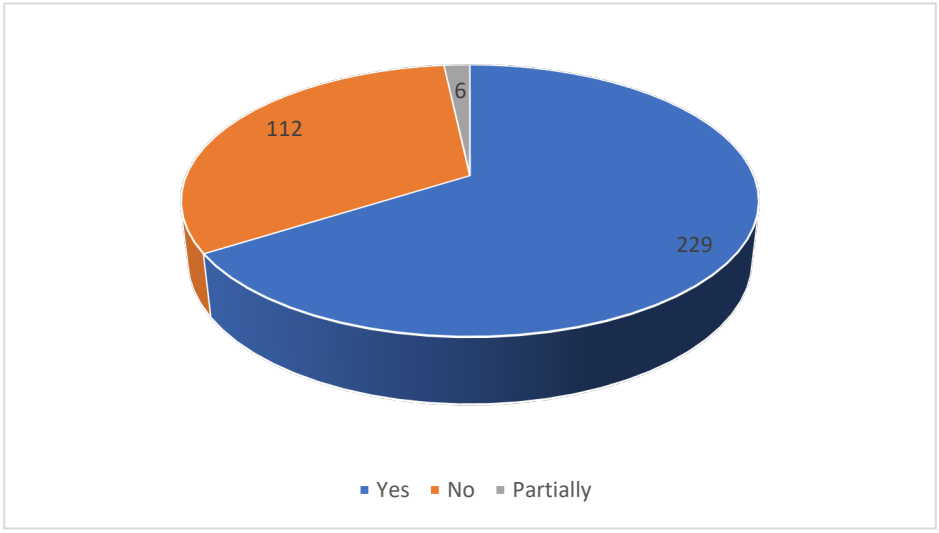


Figure 6. Participants of the study working directly with CE. Source: Research data.

Figure 6 shows that 229 participants, or about half of the sample, said they work directly in the circular economy area, while 112 said they do not. However, the majority of them justify their involvement by stating that they work with CE for research or study purposes; only six participants partially stated they do not deal with CE. Figure 7 shows the respondents' statements related to their perceived level of knowledge on CE.

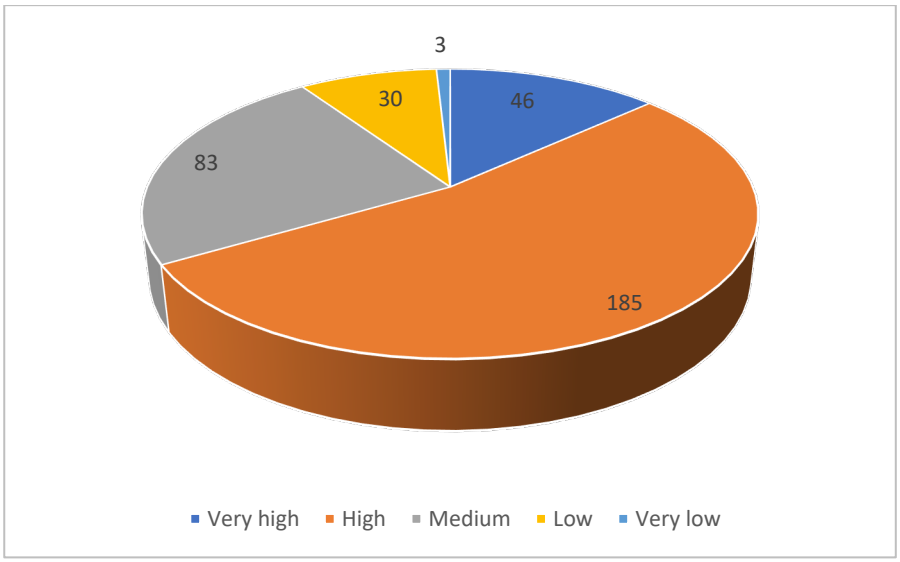


Figure 7. Level of knowledge on CE of participants of the study. Source: Research data.

The majority of 231 participants reported that they have a 'Very high' (46) to 'High' (185) level of knowledge on CE. Eighty-three participants stated that they had a 'Medium' knowledge, which can be explained by the fact that many of them were working in the related fields of sustainability at the time of the study. Only 33 participants stated that their knowledge level ranged from 'Low' (30) to 'Very low' (3). These results corroborate that the majority of participants were able to express their opinions on the questionnaire statements in a consistent manner.

4.3. Statistical Validation

Statistical validations started with checking for incomplete data, checking for normality and extreme data. One respondent did not respond to all statements and was excluded from the database, leaving 347 responses. Data normality was verified, and no extreme data were identified.

Afterwards, the common method bias analysis was performed, which is the variance of responses related to the method—such as questionnaire—and not to the constructs that the measures represent [92]. The common method bias can occur when the same instrument and the same scale are used to measure the predictor variables and the criterion variables, in addition to a single temporal measurement. To verify if there was a bias of the common method, the analysis was performed using the Harman Single Factor test, in which an exploratory factor analysis was performed forcing the extraction of a single factor. When an explained variance of less than 50% is found in the factor analysis, it is suggested that the instrument does not indicate a significant bias in the common method. The result of the Harman Single Factor test for the 240 variables showed 27.65% of explained variance, indicating the non-existence of significant common method bias.

In the next step, the reliability of the questionnaire was assessed. For this, Cronbach's alpha coefficient was used [94]. The Cronbach's alpha coefficient is 0.989, which is greater than the minimum threshold of 0.70. To evaluate sample adequacy and data suitability for factor analysis, the Kaiser–Meyer–Olkin (KMO) test and Bartlett's sphericity test were utilized. The KMO coefficient oscillates between 0 and 1. A correlation coefficient of 0.70 or higher shows that the data are sufficiently correlated for factor analysis. The KMO result was 0.859 and the Bartlett sphericity test showed a result within the limits (X^2 = 89,039.827, $p < 0.001$). These results show that the sample is adequate and appropriate for performing the factor analysis [94].

After verifying the adequacy of the data for carrying out a factor analysis, we conducted 24 confirmatory factor analyses (CFA) in order to verify the structures of the factors,

which were defined a priori, related to the strategies to induce the transition to the circular economy (24 strategies based on literature). The CFA aimed to verify the adequacy of the measurement of the constructs (strategies) through the variables used. The maximum likelihood method for factor extraction was used, taking into account only those with eigenvalues > 1 [93].

The threshold levels of the model fit indices resulting from the CFA are as under. Chi-square (X^2) and p-value (ref.: the smaller the better, for $p < 0.05$), chi-square over degrees of freedom (df) (ref.: >5), Comparative Fit Index (CFI) and Normed Fit Index (NFI) (Ref.: >0.9), Parsimony CFI (PCFI) and Parsimony NFI (PNFI) (Ref.: >0.9), Root Mean Square Error Approximation (RMSEA) (Ref.: <0.1) and Standardized Root Mean Square Residual (SRMR) (Ref.: <0.8) [93,94]. IBM SPSS Statistics (Chicago, USA) (Statistical Package for Social Sciences) and IBM AMOS, Chicago, USA (Analysis for Moments Structures) software both in version 23 were used to conduct the CFA [95]. It is noteworthy that it is not common to report the results of all indices, considering that they are redundant [93]. In addition, for each strategy, the KMO and Cronbach's alpha coefficient were analyzed again, considering ideal values above 0.7 and $p < 0.5$, respectively.

Figure 8 shows the results, which reveal that the model fit indices as mentioned above are adequate or close to adequate allowing the analysis to continue. Given the Cronbach alpha and results of the CFAs, it was appropriate to calculate the values of the strategies considering the averages of each of the statements that remained in each strategy. Further, an exploratory factor analysis (EFA) was performed to verify the grouping of strategies into factors. The reliability of the constructs (strategies) was assessed using Cronbach's alpha coefficient [94]. The result of Cronbach's Alpha was 0.962, which is greater than the minimum threshold of 0.70. To verify the internal consistency of the data and the possibility of performing a factor analysis, the Kaiser–Meyer–Olkin (KMO) index and the Bartlett sphericity test were used again, with the Varimax rotation method. The KMO result was 0.971, and the Bartlett sphericity test showed a result within the limits ($X^2 = 5323.927$, $p < 0.001$). As a result, the EFA identified four factors, with a total explained variance of 57.88%, as shown in Table 4.

Estrategy	KMO	Cronbach	df	X^2	X^2/df	CFI	PCFI	NFI	PNFI	RMSEA	SRMR
E1	0,752	0,786	14	76,584	5,470**	0,902	0,601	0,884**	0,589**	0,115***	0,066
E2	0,804	0,836	14	67,542	4,824	0,935	0,623	0,920	0,613	0,107***	0,052
E3	0,839	0,854	14	50,981	3,641	0,960	0,640	0,946	0,631	0,089	0,046
E4	0,837	0,848	19	94,785	4,989	0,936	0,635	0,921	0,625	0,109***	0,049
E5	0,836	0,859	21	107,901	5,138**	0,942	0,550**	0,930	0,543**	0,111***	0,078
E6	0,746	0,822	6	31,391	5,232	0,972	0,389	0,966	0,387	0,112	0,069
E7	0,779	0,827	4	12,080	3,020	0,988	0,395	0,982	0,393	0,078	0,036
E8	0,800	0,840	8	38,697	4,837	0,967	0,516**	0,959	0,511**	0,107***	0,044
E9	0,856	0,881	28	173,089	6,182**	0,920	0,573**	0,907	0,564**	0,124***	0,097
E10	0,772	0,835	14	67,680	4,834	0,944	0,629	0,931	0,621	0,107***	0,039
E11	0,840	0,885	31	165,161	5,328**	0,931	0,641	0,917	0,632	0,113***	0,089
E12	0,876	0,886	29	158,601	5,469**	0,934	0,602	0,921	0,593**	0,115***	0,074
E13	0,800	0,861	18	93,030	5,168**	0,950	0,611	0,939	0,604	0,111***	0,068
E14	0,841	0,857	8	31,383	3,923	0,973	0,519**	0,965	0,514**	0,093	0,031
E15	0,816	0,856	9	48,731	5,415	0,951	0,570**	0,941	0,564**	0,115***	0,036
E16	0,837	0,861	14	56,564	4,040	0,956	0,637	0,943	0,628	0,095	0,045
E17	0,848	0,873	28	145,763	5,206**	0,936	0,582**	0,922	0,574**	0,112***	0,072
E18	0,803	0,877	32	151,114	4,722	0,939	0,668	0,925	0,657	0,105***	0,083
E19	0,819	0,861	28	176,474	6,303**	0,908	0,565**	0,893**	0,556**	0,126***	0,095
E20*	0,855	0,876	12	18,016	1,501	0,994	0,568**	0,983	0,562**	0,039	0,026
E21	0,826	0,850	13	57,942	4,457	0,945	0,585**	0,931	0,577**	0,101***	0,050
E22	0,844	0,846	13	45,731	3,518	0,959	0,594**	0,944	0,585**	0,087	0,043
E23	0,811	0,853	8	35,769	4,471	0,972	0,518**	0,964	0,514**	0,102***	0,043
E24	0,847	0,881	28	127,527	4,555	0,947	0,589**	0,933	0,581**	0,103***	0,082

* p < 0,1; ** Values close to the adjustment; *** Adjusted values considering the confidence interval.

Figure 8. Statistical analysis. Source: Research data.

Table 4. Exploratory factorial analysis of CE strategies.

Total Variance Explained									
	Initial Eigen Values			Extract Sums of Squared Loads			Rotation Sums of Squared Loads		
Factor	**Total**	**% of Variance**	**% Cumulative**	**Total**	**% of Variance**	**% Cumulative**	**Total**	**% of Variance**	**% Cumulative**
1	12,806	53,358	53,358	12,384	51,600	51,600	3994	16,643	16,643
2	1017	4239	57,597	0.622	2593	54,193	3564	14,851	31,493
3	0.875	3646	61,243	0.454	1893	56,085	3370	14,043	45,536
4	0.847	3530	64,773	0.431	1796	57,881	2963	12,345	57,881
5	0.718	2993	67,766						
6	0.658	2742	70,507						
7	0.612	2550	73,058						
8	0.564	2351	75,408						
9	0.543	2262	77,670						
10	0.532	2215	79,886						
11	0.509	2122	82,008						
12	0.476	1984	83,992						
13	0.433	1806	85,797						
14	0.413	1719	87,517						
15	0.367	1531	89,048						
16	0.351	1461	90,509						
17	0.344	1432	91,941						
18	0.315	1313	93,253						
19	0.308	1285	94,538						
20	0.296	1234	95,773						
21	0.280	1169	96,941						
22	0.262	1091	98,033						
23	0.249	1037	99,069						
24	0.223	0.931	100,000						

Extraction Method: Maximum Likelihood. Source: Research data.

The composition of each factor considered scores greater than 0.5 and is presented in Table 5.

Table 5. Composition of rotated factors.

	Factor			
	1	**2**	**3**	**4**
E17	0.614			
E12	0.614			
E9	0.557			
E19	0.537			
E5	0.507			
E11				
E18				
E16				
E13				
E21		0.710		
E22		0.703		
E20		0.577		
E24		0.525		
E23		0.519		
E8			0.602	
E10			0.581	
E15			0.567	
E14			0.527	
E7			0.512	

Table 5. *Cont.*

	Factor			
	1	**2**	**3**	**4**
E6				
E1				0.603
E2				0.575
E3				0.524
E4				

Extraction Method: Maximum Likelihood. Rotation Method: Varimax with Kaiser Normalization. Converged rotation in 7 iterations. Source: Research data.

The analysis of the feasibility and reliability of the constructs (Factors) was performed using the measures Factorial Validity (Ref.: standardized coefficient $\geq$ 0.5), Individual Reliability (Ref.: square of the standardized coefficient > 0.25) and Cronbach's Alpha (Ref.: >0.7). Table 6 presents the feasibility and reliability results of the constructs.

Table 6. Feasibility and reliability of constructs.

Variable	Factor	Standardized Coefficient	Error	Factorial Reliability	Individual Reliability	Cronbach Alfa
E17	1	0.614	0.386	Yes	Yes	0.875
E12		0.614	0.386	Yes	Yes	
E9		0.557	0.443	Yes	Yes	
E19		0.537	0.463	Yes	Yes	
E5		0.507	0.493	Yes	Yes	
E21	2	0.710	0.290	Yes	Yes	0.882
E22		0.703	0.297	Yes	Yes	
E20		0.577	0.423	Yes	Yes	
E24		0.525	0.475	Yes	Yes	
E23		0.519	0.481	Yes	Yes	
E8	3	0.602	0.398	Yes	Yes	0.88
E10		0.581	0.419	Yes	Yes	
E15		0.567	0.433	Yes	Yes	
E14		0.527	0.473	Yes	Yes	
E7		0.512	0.488	Yes	Yes	
E1	4	0.603	0.397	Yes	Yes	0.798
E2		0.575	0.425	Yes	Yes	
E3		0.524	0.476	Yes	Yes	

Source: Research data.

Regarding factor validity, all factors presented standardized coefficients above the minimum threshold level of 0.50. The same happened with individual reliability. For all factors, Cronbach's Alpha results were 0.70 above the reference value, indicating that the instrument consistently and reproducibly measured each factor.

4.4. Discussion of Results

According to Schwab [96], the development of scales consists of three main steps: design of the developmental study, scale construction, and reliability assessment. Hensley [97] stated that constructs are complex and multi-faceted ideas that cannot be measured directly. Thus, the development of valid and reliable scales can be used as an approximation of the construct of interest. Based on a scale, stakeholders can obtain aid to prioritize the strategies, which is an important part of participation in EC, since one of the purposes is to increase the consumption of renewable products and the participation of the society in this process [96]. Several studies discussed the meaning of the circular economy, many of them focus on micro-level analysis, dealing with the circular economy transition of products, process and companies; however, there is no scale until this moment to address the transition at the macro level. The macro level is important considering that very often

policies and strategies of regions and countries can later induce the transition for companies and supply chains at the micro level. One example of this fact was the European Green Deal, which has promoted several changes and advances in the policies of 27 member countries. To consider a scale or questionnaire as reliable to take decisions, Kuzma and Sehnem [11] highlighted some crucial criteria to consider in order to guarantee the scale refinement: (i) use integrated and mixed methods; (ii) expand the use of qualitative methods for initial scale construction; (iii) use more refined scale refinement techniques; (iv) revalidate scale items; (v) verify the influence of sociodemographic factors on the strength of relationships; (vi) integrate different validity and reliability methods, among others.

This study meets the criteria emphasized by Kuzma and Sehnem [11], thus, it can be considered reliable to be used by policymakers and other stakeholders to take decisions concerning which strategies to prioritize in regions and countries, mainly in those we obtained more responses, to enable the transition towards a circular economy. Regarding the countries where we obtained few responses, we recommend caution to consider other variables, such as the particularities of each country or region. This is especially helpful for coalitions of stakeholders, who join a regional or national initiative to motivate and create favorable conditions to transition. For example, the European Circular Economy Stakeholder Platform, Italian European Circular Economy Stakeholder Platform and Coalition for the transition to a circular economy in Latin America and Caribbean countries.

The circular economy is part of the Operations Management (OM) area, a broad field. Some research areas in OM have no published studies to develop reliable and valid scales. Different from the areas of organizational behavior and psychology, there are several consolidated studies related to scale validation based on methods recommended by the American Psychological Association in 1985 [97]. In the operations management area, Quality Management is the area with most publications related to measuring reliability and validity in the development of scales [97]. We found just three studies aimed at developing and validating scales to measure the circular economy.

Nuñez-Cacho et al. [10] proposed the development of a scale to measure the relevance of the adoption and implementation of the circular economy initiatives in the building industry. Kuzma and Sehnem [11] built and validated a scale for measuring circular business models anchored by innovation principles. Mishra et al. [12] developed, measured, and validated an instrument to assess barriers to adopting circular economy practices in Micro, Small and Medium Enterprises (MSMEs). So, as we verify, not one of the existing studies developing and validating scales to measure the circular economy is related to the transition towards a circular economy at the macro level. Our scale is the first one to propose this approach. In addition, the Institutional Theory [44] was selected to confirm or refute the assumption that by generating a more favorable environment at the macro level (cities, regions, countries), it would be possible to enable the adoption of strategies related to the circular economy at the meso (industrial symbiosis, eco-parks) and micro levels (organizations, processes and products) [7,31,32]. Through a review of literature, report analysis, and CFA, a scale, that allowed for establishing the position of countries regarding CE, was built in response to the research questions of this work.

The scale generated in this paper follows the criteria proposed by the authors, as follows:

(i) We used an integrative literature review to gather the main strategies that enable the transition towards a circular economy and the criteria related to technical, social, environmental and economic aspects to design the developmental study.
(ii) We also defined the theory lens to analyze the results. The Institutional Theory was selected to make it possible to elaborate assertions capable to confirm or refute the assumption that generating a more favorable environment at the macro level is possible to enable the adoption of strategies related to the circular economy at the meso and micro level (cities, organizations).

(iii) We built the 5-point ordinal scale in order to enable respondents to evaluate the 24 strategies enabling the circular economy transition at the macro level, under a set of 10 criteria (technical, social, environmental and economic).
(iv) We submitted this scale to 17 experts including nine from Brazil, three from Italy, one from Spain, two from Argentina and three from the United Kingdom, which made some suggestions to improve the instrument.
(v) We applied the statistical validation process through the opinion of 347 survey respondents from 25 countries (Section 4.3 presents the characterization of the sample of stakeholders participating in this step).
(vi) After verifying the adequacy of the data for carrying out a factor analysis, we conducted 24 confirmatory factor analyses (CFA) to verify the structures of the factors defined a priori related to the strategies to induce the transition to the circular economy. We conducted exploratory factor analysis and ensured the verification of the reliability of the questionnaire, through the Cronbach's alpha coefficient, the Kaiser–Meyer–Olkin (KMO) index and the Bartlett sphericity test [93]. For all factors, Cronbach's Alpha results were above 0.70, indicating that the instrument consistently and reproducibly measured each factor. Thus, the reliability and validity of the research instrument are ensured.

So, in order to answer the RQ—How to validate a scale to prioritize the strategies considering multiple criteria related to social, environmental, economic and technical issues in a systematized way, we used mixed methods, with qualitative (semantic validation) and quantitative approaches (statistical validation), besides the integrative literature review to conduct the steps emphasized by Schwab [96]: design the developmental study, build the scale and assess the reliability and validity of the scale. We meet the requirements highlighted by Kuzma and Sehnem [11]. The qualitative methods were used for the initial scale construction, scale refinement and revalidation of scale items. The quantitative methods were used to verify the influence of sociodemographic characteristics and to ensure the validity and reliability of methods.

It is not our purpose to discuss, in this study, how the prioritization occurs in the countries participating in the survey because this paper intends just to demonstrate how to construct and validate a questionnaire to be applied for this purpose. The scale also does not intend to overfit all countries, considering that this study has a limitation related to the sample, which was not probabilistic and because we did not obtain sufficient responses from all countries participating in this study. However, for purposes of exemplification, we can denote the policies and initiatives already adopted by the countries from which we obtained more responses, namely, European Union, Denmark, Italy, Brazil, and Pakistan. The first two being emerging economies, which still have policies and initiatives more related to solid waste and its management. While Italy and Denmark, as they are developed countries, and members of the European community, have more consolidated policies for the transition to the circular economy, which can result from coercive isomorphism. The specific guidelines and legislation of the countries with more responses are shown in Table 7.

Table 7. Guidelines on circular economy by countries with more responses.

Country	Description
European Union	Over the past decades, the European Union has put in place a broad range of environmental legislation to boost a European circular economy, such as the Waste Framework Directive, the Landfill Directive and the Packaging Waste Directive. The action plan focuses on the action at the EU level with high added value. Making the circular economy a reality will, however, require long-term involvement at all levels, from Member States, regions and cities, to businesses and citizens.

Table 7. *Cont.*

Country	Description
 Denmark	In 2018, the Danish Minister of Environment and Food and the Minister of Industries, Business and Financial Affairs launched the government's new strategy for the circular economy. The new strategy, which has six focal areas and 15 activities, is based on the suggestions of the government's Advisory Board on the Circular Economy. These initiatives aim to support the Danish transition into a more circular economy, e.g., by strengthening the companies' opportunities to become a motivating force for the circular transition and to create a well-functioning market for waste and reused goods. The Danish government has set aside EUR 16 million to accelerate the transition.
 Italy	Italy has created, in 2018, the Italian Circular Economy Stakeholder Platform—ICESP, initiated by Energia Nucleare ed Energia Alternative (ENEA), mirroring the European initiative (ECESP) to enable initiatives, experiences, the discussion of critical issues and perspectives and to promote specific dedicated actions related to the transition towards a circular economy. ICESP has set up six working groups, which meet periodically to draw up reviews, technical reports and studies on the topics covered in the course of their activities as well as to map out good circular economy practices, in connection with ECESP. Some regions have specific legislation, as the Emilia Romagna region which enacted the first law related to circular economy.
 Brazil	Currently, there is no national strategy in Brazil for implementing a circular economy. However, there are some policies, programs and plans to boost the transition to circular economy practices, such as the CE100 initiative from EMF, in which some industries and stakeholders in Brazil have adhered. The Confederation of Brazilian Industries (CNI) and the Ministry of Science, Technology, Innovation and Communication (MCTIC) have tried to engage industries, research centers, universities and other segments of society to discuss the transition towards the circular economy. In 2010, Brazil enacted the Brazilian Solid Waste Policy (PNRS), which was the first public policy to be adopted in waste management. Within this framework, themes such as EC have become the focus of discussion.
 Pakistan	Pakistan lacks a comprehensive national strategy and legislation about the circular economy. Recently, Pakistani government has taken some initiatives regarding CE, including possible removal of plastic bags. Pakistan Environmental Protection Act (PEPA) prohibits discharge of waste in an amount or concentration that violates the National Environmental Quality Standards (NEQS). Hazardous Substances Rules (2003) and 2016 prevent the release of hazardous substances as wastes. National Environmental Policy (2005) and Import Policy Order (2016) prevent the import of hazardous wastes to Pakistan. Guidelines for Hospital Waste Management (2005) and 2014 since 1998 prepared by the Environmental Health Unit of the Ministry of Health, Government of Pakistan relates to managing wastes that are produced by hospitals. Prime Minister's Committee on Climate Change, which was established to ensure that Pakistan fulfills requirements of Clean Development Mechanism (CDM) under the Kyoto Protocol. This committee has a sub-divisional level technical committee on Waste Management. The Clean Green Pakistan Movement (CGPM), which was launched in 2018, addresses solid waste management, liquid waste management, total sanitation and safe drinking water and plantation. Clean Green Index: A "Clean-Green Cities Index" has been initiated in 20 cities to trigger a shift towards improved waste management and sanitation.

Source: Adapted with permission from [98].

As we can observe in Table 7, the European Union, Italy, and Denmark have more disruptive goals and initiatives, considering the rethinking of production and consumption models, more aligned with a proactive stance towards the transition, which is a consequence of the policies of the European community, which most actively engage in the CE transition [99]. These two countries rank among the top European nations in terms of CE performance [100]. These nations have higher GDPs, superior infrastructure, superior educational systems and advanced R&D (ibid). In line with this, Grdic et al. [101] showed a connection between economic development and circular economy indicators. Nevertheless, even in Europe, there are differences in the performance of the countries regarding CE. Some European countries have more legislation, policies and initiatives, while others are still in their infancy considering the circular economy transition. However, the mandatory guidelines from the European Union can impel these countries from adapting over time. In contrast, developing countries, including Brazil and Pakistan, do not have such a national strategy regarding the CE transition. In Brazil, there is a solid waste management policy at the national level. These countries lack a national strategy for transitioning to a circular economy. Instead, these countries have national-level policies regarding waste management, which is the lowest degree of circularity or the minimum level of the circular economy [102]. To reach the minimum level, a country must have at least one waste management policy enacted. Therefore, the first two nations have policies regarding waste management, which shows their involvement in the transition to CE, yet the transition pattern is expected to be different compared to the first two developed nations. We are not stating that we can generalize that all developed or developing countries have a reactive or proactive attitude towards the transition. However, in the results obtained, considering these four countries, this tendency can be observed, despite it is not the purpose of this paper. Future studies can compare the countries related to the prioritization of strategies conducting the transition towards a circular economy, considering their particularities in terms of legislation, guidelines, and initiatives. Cramer [15] analyzed the level of development of sixteen countries, including Italy and Brazil, related to the transition of the circular economy considering the network governance concept. The authors found that Italy generally has a medium level, while Brazil has a low level but growing towards the transition to a circular economy model.

Thus, concerning the statistical validation of the questionnaire, the first contribution is a design of the dimensions that comprise the scale. What dimensions do experts consider most important when measuring the implementation of the circular economy at the macro level? The factor analysis suggests classifying the 24 strategies into four factors. The first factor includes strategies such as E5—Sectoral Agreements, E9—Industrial Symbiosis, E17—Eco-innovation and eco-design and E19—Sharing economy. The second factors consist of the strategies including E20—Getting value out of biomass, E21—Water reuse, E22—Energy efficiency, E23—Food waste reduction and E24—Construction and demolition (C&D) waste management. The third factor includes strategies such as E7—Financial incentives and/or support and fiscal measures, E8—Stakeholders involvement, E10—Partnerships with research and development (R&D) organizations, E14—Sustainable product policy and E15—Green or sustainable procurement. The last factor (i.e., the 4th one) consists of strategies such as E1—Inter-firm collaboration, E2—Waste management directives and E3—Reverse logistics.

Another contribution to be pointed out is the development of critical analysis at the country and region level of sustainability indicators (environmental, social, economic and technical). The scale that has been provided can be used for the comparative evaluation of the improvement of the environmental performance of the countries and regions. Besides, it can be helpful for the identification of problematic areas in which more effort is required to advance, the cost analysis benefit, and knowing the weights of each dimension and others. With this, a need for integration of these indicators into the country decision-making becomes evident in order to achieve its effective implementation.

This research proposes and tests a novel scale for measuring the macro-level transition towards a circular economy that can aid decision-makers in policymaking at the governments and the stakeholders involved in the circular economy transition. The results can serve as input to evaluate, based on the opinion of several stakeholders, the strategies to prioritize in public policies to enable the transition towards a circular economy and propose some indicators to be used in this context. According to a previous literature review report, understanding CE's similarities and disparities in various geographies can speed up the global transition to CE [18,103]. The circular economy is high on the developed countries political, intellectual and managerial agendas, particularly those in the European Union, Japan and the United Kingdom [13,14]. Otherwise, in developing countries, practices and policies related to waste management are still in their infancy [23–26,98]. These economies are still debating the circular economy and face different realities regarding resource availability, varying government policies and consumer behaviour from developed economies [103]. The transition to a new economic model is not a quick and easy process; instead, it requires a systemic and cross-sectional approach involving several stakeholders and strategies from a sustainability perspective [98,104].

The scale developed and tested in this study will help countries and regions measure and compare their progress towards the CE transition. Regarding the practical application, our study provides a measurement scale applicable at the macro level. It is helpful for both countries and regions because these indicators are already being measured by regions and countries, thereby guaranteeing the applicability and the possibility of using dynamic indicators that allow for comparing the degree of implementation of the CE between different regions and countries. Government and public administrations are concerned about environmental issues, especially CO_2 levels, generated waste and scarcity of materials. Our work contributes by providing a scale to evaluate and establish a ranking of implementation of CE, which allows us to make decisions about sustainability and classify strategies based on sustainability and technical criteria.

5. Concluding Remarks, Limitations and Future Directions

Transitioning to a circular economy requires measures at the macro level. There is a lack of research about validating measurement scales regarding the circular economy at the macro level. This research fills this gap. This study contributed by proposing and validating a questionnaire based on 24 strategies that enable the transition towards a circular economy measured by ten criteria based on the dimensions of sustainability (social, environmental, economic) and technical issues. To test the construct validity of the items in the instrument, Cronbach's Alpha was used, which shows that it is consistent and reproducible.

The main contribution is the proposition, development, and validation of a comprehensive questionnaire that can be used to analyze, at the macro level, the prioritization of the 24 CE strategies under a comprehensive set of ten criteria that can measure the perceptions of stakeholders related to the importance of strategies considering technical, social, environmental and economic issues. The results confirm 24 CE strategies into four factors/dimensions: Factor 1—Eco-innovation and eco-design, Eco or circular cities, Industrial symbiosis, Sharing economy and Sectoral agreements; Factor 2—Getting value out of biomass, Water reuse, Energy efficiency, Food waste reduction and Construction and demolition (C&D) waste management; Factor 3—Stakeholders involvement, Partnerships with research and development (R&D) organizations, Sustainable product policy, Green or sustainable procurement and Financial incentives and/or support and fiscal measures; and Factor 4—Inter-firm collaboration, Waste management directives and Reverse logistics.

Based on the findings, the instrument/questionnaire could be used as a diagnostic tool to analyze which strategies aimed at the circular economy are prioritized at the macro-level by countries, regions and cities, considering the limitations of the sample and the number of results obtained by country. We cannot extrapolate the use of the scale for those countries with fewer respondents, considering the limitations we explained. However, it is essential to emphasize that the single-unit responses from some countries did not bias the results

because we considered the total value of the sample in the analysis. It can be helpful for researchers and practitioners from public and private spheres, involved in the coalitions and organizations from several segments and sectors of acting, committed to proposing actions to enable the transition at the macro level. These stakeholders' coalitions have been implemented in several continents, such as Asia, Latin America and European, to create favourable conditions for countries, regions and cities to transition to a circular economy model.

This study has some limitations that must be acknowledged to help drive further research. Firstly, we recommend that future studies could consider larger sample sizes. Although we obtained 347 responses from 25 countries, the participation was more concentrated in the countries of the location of researchers of this study: Brazil, Italy, Pakistan, and Denmark; in the 21 other countries, the participation of the stakeholders was meagre, a cluster analysis could be conducted considering a minimum of responses of the countries. Secondly, the study focused on strategies adopted at the countries' macro level and did not consider the meso-level perspective of the companies/organizations or the micro level, considering enterprise processes or products. Thirdly, the questionnaire was elaborated and validated in four languages: Brazilian Portuguese, English, Italian and Spanish; it can limit the participation of participants not familiar with these languages. Additionally, the questionnaire was self-administered; thus, the stakeholders' perceptions are self-reported measures and may involve some subjectivity. In addition, this study could not be generalized for the entire population because it does not take a broad sample size considering participants from every age group, socio-economic condition, gender, ethnic group, country, sector, segment, size of companies and others.

Other limitations are related to the circular economy elements not approached in this paper, such as the assessment of strategies in countries, regions, cities or organizations with institutional voids; the preparation/planning of these institutions to use new approaches related to CE; the increasing of integration of the CE and emerging industry technologies.

Considering that our purpose is not to exhaust the research on the topic, we believe that all the limitations indicate possible avenues for further studies to provide a more robust comprehension of the phenomenon studied, related to the prioritization of strategies to enable the transition towards a circular economy. Despite the limitations, the study offers several contributions.

Despite the limitations highlighted, we may conclude that the primary purpose of this study was accomplished, proposing an operational measure to prioritize the strategies enabling the circular economy through the development and validation of a questionnaire. It is essential to point out that it was not our intention to exhaust the topic, and we recognize that it needs further development.

Author Contributions: Conceptualization, P.G., B.d.O.V., F.H. and A.L.N.R.; methodology, P.G., L.C.e.S., A.B., J.R., E.R.J. and F.H.; validation, P.G., L.C.e.S., A.B., J.R. and E.R.J.; formal analysis, P.G., L.C.e.S., E.R.J., F.H. and A.L.N.R.; investigation, P.G., F.H., B.V.W., S.F., J.R. and A.B.; writing—original draft preparation, P.G., B.d.O.V. and L.C.e.S.; writing—review and editing, P.G., A.B., J.R., B.V.W., F.H., S.F., E.R.J. and A.L.N.R.; supervision, P.G., A.B. and L.C.e.S.; project administration, P.G.; funding acquisition, P.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received financial support from Brazilian National Council for Scientific and Technological Development (CNPq) and National Council for the Improvement of Higher Education (CAPES) through scholarships.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki. Ethical review and approval were waived for this study due to not involving experiments with humans and animals, vulnerable population and does not involve any sensitive topic of study. The informed consent was delivered and agreed by all participants.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: We acknowledge the Brazilian National Council for Scientific and Technological Development (CNPq) and National Council for the Improvement of Higher Education (CAPES) for the scholarships provided by some authors of this project.

Conflicts of Interest: The authors declare no conflict of interest.

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