

Article

Assessment of Circular Economy within Portuguese organizations

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Abstract: The move towards a new Circular Economy (CE) economic model has been advocated and supported in Portugal, however, there is limited research on this topic. To address this gap, a quantitative research based on an online survey was carried out among 99 Portuguese organizations, encompassing a wide range of sectors and sizes. The results show that CE is regarded as a strategic and relevant issue for profitability and value creation. Furthermore, the perception that it requires the adoption of new business models in addition to the classical “reduce, reuse, and recycle” approach is growing. Moreover, based on the hypotheses raised, results suggest that the level of CE adoption is positively impacted by the status of the EMS (Environmental Management System) certification and the willingness to improve the environmental performance and achieve a sustainable business model. However, CE activities are still relatively modest and a friendlier context (fiscal, legal, organizational, etc.) and the stronger support from supply chain agents and consumers are required. Future research should focus on how to design and shape the transition from a linear to a CE economy, and to ascertain if the positive attitude towards CE is materialized in changing the way business is done.

Keywords: Circular economy; sustainability; environmental management; resource management; strategy; motivations; knowledge; challenges.

1. Introduction

The need to deal with a range of global issues, such as environmental protection, health improvement, and fight against poverty lead the United Nations to propose a set of 17 Sustainable Development Goals that should be addressed by adopting an integrative and indivisible approach to balance the economic, social, and environmental dimensions of sustainable development [1]. The world resources are finite, and the economic development is generating, on a global scale, increasing consumption levels, contributing to resource scarcity and increased waste generation.

The Circular Economy (CE) economic system aims to conciliate economic and environmental performance, by adopting an innovative approach to address the relationship between business and the environment. Through the implementation of closed loops and regenerative and restorative physical and economic cycles, and the combination of maintenance, repair, reusing, refurbishment, remanufacturing, and recycling processes, CE aims at leverage the overall sustainable production and consumption [2, 3, 4].

The prevailing linear traditional economic model “take-make-consume-disposal” or “extract-produce-use-dump material and energy flow” take for granted that resources are infinite, which is a sustainability problem since it raises economic, environmental, and social concerns, as it depletes the resources and pollutes the environment. The resource scarcity fosters higher price value and volatility, which impacts negatively on value creation and capture. Moreover, consumer preferences

are changing towards more environmental friendly products and new sharing versus ownership models emerge [2, 3, 4].

On the other hand, the CE approach is based on the concept of improved resources management by using by-products and wastage from processes and consumers as a direct or indirect source of inputs for other processes, minimizing resource scarcity and overexploitation [2, 3, 4]. CE enhances firms' competitiveness and mitigates risks, without endangering the environment and causing resources scarcity, contributing to a sustainable and enduring economic growth while creating tangible and intangible benefits for companies and their stakeholders [5]. CE is supported by a wide range of scientific areas such as environmental science, process engineering, biology, ecology, sociology, management, economics, territorial and urban planning, regulations [5, 6, 7, 8] and its application covers diverse activity sectors [9].

Since authors such as Boulding envisaged in 1996 a "spaceman economy" that would operate by reproducing the initial limited stock of inputs and recycling waste outputs [10], the concept of CE has evolved, and a considerable number of scholars, academics, practitioners and policy-makers currently concurs on the need to move towards a new economic model whereby materials and energy from discarded products do not leave the economic system [2, 11]. CE is expected to foster the adoption of alternative flow model economic systems (cyclical and regenerative) and positively impact on both the environment and on the economic growth [3, 12, 13, 14]. CE entails a new business model based on the close-loops of reuse and refurbishment that can deliver a higher economic and environmental value than those models solely based on recycling and energy recovery [15].

CE is framed on the principles of the 3Rs (reduce, reuse, recycle) and the 6Rs (reuse, recycle, redesign, remanufacture, reduce, recover) and some of CE definitions are summarized in Table 1. The mainstream research stresses that through the adoption of a CE approach organizations may attain benefits addressing simultaneously and holistically the economic, environmental, and social dimensions of Sustainable Development:

- The increase in recycling and the more efficient resources and renewable energies utilization, resulting in fewer emissions, optimized resources utilization and the minimization of the negative environmental impacts on the global ecosystem [13]);
- An improvement of business competitive position [16] and social positive outcomes (e.g., jobs creation [17, 18] by maintaining the highest value of materials and products with increased remanufacturing, refurbishment and re-use of products and components in addition to product life extension, product as service, sharing models and change in consumption patterns;
- In addition to cost savings and value maximization, CE minimizes the risks of the scarcity of virgin materials and price variations which a demand-driven price volatility in raw material markets entails [19].

Table 1. Summary of CE definitions

Author	Definition
Ellen MacArthur Foundation, 2012, 2014 and 2015 [3, 4, 16].	CE is "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models". The overall objective is to "enable effective flows of materials, energy, labor and information so that natural and social capital can be rebuilt."
European Environmental Agency, 2016 [13]	"CE provides opportunities to create well-being, growth and jobs while reducing environmental pressures. The concept can, in principle, be applied to all kinds of natural resources, including biotic and abiotic materials, water and land" [13].
Morgan and Mitchell, 2015 [17]	CE is "an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extracting the maximum

	value from them whilst in use, then recovering and reusing products and materials."
Sauvé et al., 2016 [7]	CE refers to the "production and consumption of goods through closed-loop material flows that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)."
Ghisellini et al., 2016 [5]	"CE involves the radical reshaping of all processes across the life cycle of products conducted by innovative actors and has the potential to not only achieve material or energy recovery but also to improve the entire living and economic model."
Yuan et al., 2006 [20]	"Although there is no commonly accepted definition of CE so far, the core of CE is the circular (closed) flow of materials and the use of raw materials and energy through multiple phases."
Chen, 2009 [21]	"To solve the contradiction of limited resources and the increased consuming desire of human being[s], and to make use of natural resources rationally to achieve sustainable development, the circular economic development mode follows the pattern of ecological circulation and is based on the recycling of material resources."
Murray et al., 2017 [8]	"The Circular Economy is an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being."
Zink and Geyer, 2017 [22]	"The core of the circular economy refers to three activities: reuse at the product level (such as 'repair' or 'refurbishment'); reuse at the component level (e.g., 'remanufacturing'); and reuse at the material level ('recycling')."
Korhonen et al., 2018 [23]	"CE is a sustainable development initiative with the objective of reducing the societal production-consumption systems' linear material and energy throughput flows by applying materials cycles, renewable and cascade-type energy flows to the linear system. CE promotes high-value material cycles alongside more traditional recycling and develops systems approaches to the cooperation of producers, consumers and other societal actors in sustainable development work."

Masi et al. [15], based on a systematic literature review identified three major clusters of CE definitions, namely "CE as a new label for an existing concept", "CE as a prescriptive set of existing concepts and practices" and "new definitions that integrate economic, environmental, and social considerations" [15]. These authors, while acknowledging the absence of a comprehensive CE definition, proposed a set of 4 major goals to map the CE definition as a new economic model based on regenerative and restorative cycles aiming at decoupling economic growth from resource depletion and environmental degradation, increasing the overall system resilience and creating and preserving economic, environmental, and social value to maximize human well-being [15].

However, there are several barriers to overcome aiming at a successful adoption of CE, such as the lack of a clear business case, administrative burdens to switch to a circular economy business model, poor support from the supply chain, lack of technical and technological knowledge, shortcomings of the company environmental culture, absence of information and lack of proper government and legislative support [24]. Rizos et al. [24] based on a literature review and on case studies conducted among SMEs concluded that albeit the existence of policies and measures to leverage CE in Europe, several significant barriers remain, and additional European and national policies are needed. Winas et al. [25] identified the lack of information exchange, inadequate materials flow and transportation, and lack of regulation, incentive(s), and infrastructure required for resource exchange as constraints precluding the success of CE activities. Moreover, the research has focused more on the practical and technical levels of physical flows of materials and energy in production-consumption systems and less on the values, societal structures and cultures that can successfully foster CE [23].

105 A great deal of countries and regions, such as the European Union (EU), Germany, the United
106 States, China, and Japan developed their own CE plans. The EU considers CE as a primary goal for
107 research and innovation policies at the firm level [26, 27], but some tensions and shortcomings related
108 to CE adoption need to be overcome, such as, the implication of increased consumers and
109 organizations responsibility and awareness, and the adoption of new consumption patterns,
110 compatible with CE concepts and approaches [8]. In that regard, the European Environment Agency
111 (EEA) proposes the following characteristics for the CE (Table 2):
112
113

Table 2. Key characteristics of a CE (EEA, 2016) [13]

CE Category	Key characteristics
1: Less input and use of natural resources.	<ul style="list-style-type: none">• Minimized and optimized exploitation of raw materials, delivering more value from fewer materials;• Reduced import dependence on natural resources;• Efficient usage of all-natural resources;• Minimized overall energy and water usage.
2: Increased share of renewable and recyclable resources and energy.	<ul style="list-style-type: none">• Non-renewable resources replaced by renewable resources within sustainable levels of supply;• Increased share of recyclable and recycled materials that can replace the use of virgin materials;• Closure of material loops;• Sustainably sourced raw materials.
3: Reduced emissions.	<ul style="list-style-type: none">• Reduced emissions throughout the material cycle by consumption of less raw material and sustainable sourcing.• Less pollution through clean material cycles.
4: Fewer material losses/residuals.	<ul style="list-style-type: none">• Build-up of wastage minimized.• Incineration and landfill limited to a minimum.
5: Keeping the value of products, components, and materials in the economy.	<ul style="list-style-type: none">• Extended product lifetime keeping the value of products in use.• Reuse of components.

114
115 Portugal, being a member state of the EU, has an action plan to promote CE [25, 28] and research
116 studies report that Portuguese consumers claim to be supportive of CE [29]. However, there is a lack
117 of research concerning the motivations, the knowledge, the adoption, and the suggestions to promote
118 CE within Portuguese companies. According to the Portuguese Central Bank (Banco de Portugal) the
119 national public debt is about 130% of GDP (Gross Domestic Product) and the exports account for
120 nearly 80% of imports [30]. The CE concept is applied in Portugal for waste management mainly [25,
121 31] albeit the existence of a few business models that apply reuse concepts (e.g., cork industry). CE
122 may aid Portugal to improve its GDP and reduce the trade deficit, by being less dependent on raw

material imports to produce goods while minimizing the risks of price volatility or political instability. It can also lead to job creation in areas such as reuse, repair, remanufacture of products and minimize the negative impacts on the environment of the economic activity and the societal lifestyles.

As previously mentioned, there is a lack of awareness concerning CE among Portuguese companies and this study aims to address this gap, by conducting a quantitative research based on an online survey carried out throughout the first two weeks of May 2018, among 99 Portuguese organizations. The remaining paper is organized as follows: Section 2 is devoted to the literature review and to the identification of the main strategies, motivations, barriers, and actions to promote CE. Section 3 describes the research method adopted. The research findings are reported in Section 4. Section 5 proceeds with a systematic discussion of the results and the theoretical and practical implications, as well as the shortcomings and potential future research paths.

2. Literature review

The mainstream literature identifies a set of benefits derived from CE adoption, namely: fewer environmental emissions, decrease in resources consumption [13], privileged business competitive position [15] and the minimization of risks [19].

The characteristics of the organizations, such as the type of business, size, activity sector might influence the motivations, knowledge, and applicability of CE. As an example, research on the benefits of Environmental Management Systems (EMS) implementation pointed out that the perceived benefits are dependent on the organization size (bigger organizations more accustomed to alignment with business strategy and performance measurement and smaller ones having more flexibility and less formality) [32].

Jonker et al. [33], based on the results collected throughout a research among Dutch companies, concluded that those organizations that adopt CE business models have considerable lower raw materials and energy consumptions costs and higher recycling and product reuse and repair rates. Additionally, more innovative organizations and those that adopt collaborative business models evidence higher levels of CE adoption. A study from the Ellen MacArthur Foundation, SUN and the McKinsey Center for Business and Environment estimates that, due to technological and organizational innovations and productivity growth, CE economy would generate 1.8 trillion total benefits in the mobility, food, and the built environment sectors, due to savings in resource costs and externalities, such as health impacts from air pollution [34].

The urge for a transition towards CE has been pushed by a significant number of researchers, business practitioners, politicians, and international organizations [3, 11]. However, to supersede the linear “source, use and waste” economy by a CE model, an integrated approach that focuses on a long-term system change or transition is required [29]. Several factors have been identified as enablers (or barriers) for the successful implementation of CE. The environmental culture of the organization (its managers and employees) favoring the protection of the environment and the adoption of CE is one major dimension to be considered [35]. The cost/benefit assessment of CE demands for a long-term perspective and should consider the business and the processes risks and opportunities. Furthermore, the resistance to change from the existing to a novel business model must be overcome [36].

CE also demands for a coherent change in consumer behavior, governmental policies, business practices and in several subsystems, such as energy, logistics, and financial subsystems. It can leverage novel business models and new value and supply chains, impacting several business processes such as, design, supply, production, delivery, usage, disposal, collection, sharing, repair, upgrading and remanufacturing, however, significant changes in infrastructure and supply chain management may be required. Additionally, it should be ensured that CE systems perform better than linear ones, e.g., by addressing the potential excessive use of transportation and energy, or unattractive working conditions in areas as product recovery [15]. Life cycle analysis can be a very

173 helpful tool to assess overall social, economic and environmental performance of new/proposed
174 solutions.

175 Resistance to change may arise due to risk aversion, lack of information and knowledge or
176 inaccurate perceptions. The need for the organizations to deal with the appropriate information
177 concerning the CE knowledge and benefits and assign clear responsibilities for CE, has been
178 highlighted in a study based on a survey conducted among 300 European companies. A great deal of
179 firms was unaware of CE and its meaning. However, when given a straightforward definition of CE,
180 most respondents reported that were already making efforts to recycle and repair and identified
181 waste management as a new business opportunity [37]. Issues such as confidentiality, trust, and
182 competition also need to be considered to allow the proper sharing of knowledge and product
183 information along the overall companies' ecosystem, involving co-creation and partnerships amongst
184 the organization suppliers, customers, and consumers, through the product life cycle.

185 The adopting of a CE business model can be more complex and costly to manage, and the
186 environmental practices may increase the administrative work load due to more demanding
187 monitoring and reporting activities (including to various authorities, using different supports) of
188 environmental performance data, requiring the involvement of company experts or external
189 consultants [36, 38].

190 From a stakeholder point of view, the adoption of CE requires a collaboration from all parties
191 across the supply chain and is likely to increase the overall supply chain logistical and governance
192 complexity possibly requiring novel approaches of collaboration with other market players [36, 39].
193 The transition towards a CE economy also asks for a change in consumer behavior and in many cases,
194 there is not a significant demand for green products [40]. A stronger community involvement, public
195 education concerning CE, and proper media coverage are critical to support CE initiatives. Moreover,
196 stakeholders should be aware of CE potential economic, environmental, and social benefits and
197 barriers. [25].

198 The implementation of a CE production/business model entails much more than just decreasing
199 waste through recycling [3]. It demands the reduction of raw materials consumption, the design of
200 environmental friendly products that may easily be recovered and reused (eco-design), a longer
201 product life proper maintenance, the use of recyclables in products and the recovery of raw materials
202 from waste flows [36]. Thus, CE adoption demands for significant changes and investments to modify
203 the existing linear models in domains such as planning, production, and supply chain management
204 [36]. It also implies a shift from material intensive business models to business models based on
205 services and enhancing more collaborative partnerships.

206 Since the current legal and financial frameworks are deeply rooted in a linear economic view,
207 institutional and legal barriers need to be overcome aiming at the CE success [38]. Additionally, there
208 are some vested interests that must be considered (e.g., increase materials and product sales) and
209 the need to manage an enlarged ecosystem of diverse stakeholders which will require considerable
210 investments in the short term (e.g., additional competencies and knowledge, new contracts, new
211 product and process designs, and new equipment) with long-term paybacks [39]. The access to capital
212 is, therefore, a relevant enabler for the CE successful adoption [36, 41]. In addition to stakeholders'
213 support, the existence of proper government policy instruments (economic and regulatory, such as
214 subsidies and tax incentives), supportive CE laws and regulations [38], and training availability, are
215 also needed to contribute to an integrated top-down and bottom-up approach to foster the successful
216 implementation of CE.

218 3. Materials and Methods

219 A quantitative research, supported on a survey held online throughout the first 2 weeks of May
220 2018, was the research method adopted to understand the level of CE application and the
221 motivations, knowledge, and ways of promoting CE, within Portuguese organizations. The survey
222 was designed taking into account the insights collected from a thorough and extensive CE literature
223 review, namely Ghisellini et al. [5], Rizos et al. [24], Fonseca and Domingues [32], Jonker et al. [33]

224 and Lakatos et al. [42]. The research instrument adopted a similar structure from those instruments
225 reported in previous studies [29, 32, 33] and it was pre-tested with an academic and a practitioner CE
226 expert. Construct reliability was tested and validated with Cronbach Alpha (greater than 0.7).

227 The survey structure encompassed 4 major group of questions addressing the following main
228 themes:

- 229 • Organization characterization: headquarters localization, the market in which the
230 organization operates, activity sector, economic classification code, number of
231 employees and the status of ISO 14001 certification. This section ended with questions
232 to assess with a Likert five-point agreement scale - (1) Never; (2) Rarely; (3) Occasionally/
233 Sometimes; (4) Most of the times; (5) Always – the level of agreement with the
234 application of 10 possible CE strategies in the organization;
- 235 • Level of motivations for CE (9 items), Level of CE knowledge (5 items) and Level of CE
236 intensity in the organization (7 items); all assessed with a Likert five-point agreement
237 scale – 1 (Totally disagree); 2 (Disagree); 3 (Neither agree or disagree); 4 (Agree); (5)
238 Completely agree;
- 239 • Level of CE applicability in the organization (15 items) assessed with a Likert five-point
240 agreement scale – 1 (Totally disagree); 2 (Disagree); 3 (Neither agree or disagree); 4
241 (Agree); (5) Completely agree;
- 242 • Level of agreement with actions to promote CE (10 items) assessed with a Likert five-
243 point agreement scale – 1 (Totally disagree); 2 (Disagree); 3 (Neither agree or disagree);
244 4 (Agree); (5) Completely agree;
- 245 • And lastly the characterization of the respondent organizational role, the number of
246 years involved with the organization and an open question to gather qualitative
247 feedback.
248

249 Likert-type scales are often adopted in research and scales using 5 or 7 scale points are the most
250 common [43]. The 5 points scales were adopted to allow comparability with previous research studies
251 on ISO 14001:2015 application [32]. Circa 2000 companies included on a commercial database with
252 the top (export and sales volume) Portuguese commercial entities (and their hierarchies) covering a
253 wide range of sectors were contacted by e-mail. The data were collected anonymously through an
254 automatic online database. The sample comprised a total of 99 organizations and the overall response
255 rate was 5%. The survey results were monitored during the survey period to check for possible non-
256 respondent bias using “wave analysis” [44] and no significant differences were found between early
257 and late respondents. Although these measures aimed to minimize possible bias errors inherent to
258 the survey methodology, it should be acknowledged that such a high non-respondent rate could
259 indicate lack of CE awareness within non-respondents, and that the survey results should be
260 consistent with the population of the more CE aware organizations. Nevertheless, this low response
261 rate should be acknowledged as a shortcoming of this study.

262 The statistical tests and calculations (after ordinal to numerical transformation of the Likert scale
263 type of answers) were performed with IBM Social Sciences Statistical Package (SPSS) v. 22 software.
264 To assess if some variables, measured on an ordinal scale, differed based on other variables (namely
265 those related to the characterization of the company), the following research hypotheses were raised
266 (based on the results of the literature review and the descriptive statistics) and tested with non-parametric
267 Kruskal–Wallis one-way analysis of variance statistical test:

268
269 Dimension 1—Organizational goals and strategies

270 Research Statement: The definition of strategic goals and policies in the organization (G 2.1c, G
271 2.1d, G 2.1i, G 2.1u, G 3i and G 3j, see Tables 2 – 7 for the variables descriptions) differ according to
272 the ...

273 Hypothesis 1 (H1). ... market in which the organization operates.

274 Hypothesis 2 (H2). ... activity sector where the organization operates.

275 Hypothesis 3 (H3). ... dimension of the organization (N° of employees).

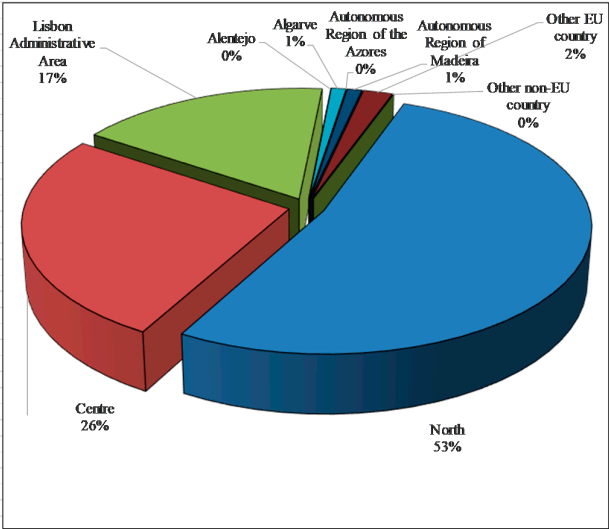
276 Hypothesis 4 (H4). ... the status and maturity (years) of the EMS certification
277 Hypothesis 5 (H5). ... organizational role of the respondent.
278
279 Dimension 2— level of CE intensity
280 Research Statement: The level of CE intensity in the organizations (G 2.2a to G 2.2o, see Table
281 5 for the description of variables) differ according to the ...
282 Hypothesis 6 (H6). ... willingness to improve the environmental performance and create
283 environmental value (G 2.1c)
284 Hypothesis 7 (H7). ... willingness to have a better access to raw materials to prevent its scarcity
285 activity sector where the organization operates (G 2.1d).
286 Hypothesis 8 (H8). ... willingness to have a sustainable business model dimension of the
287 organization (G 2.1i).
288 Hypothesis 9 (H9). ... The agreement that CE is an integral part of the organizational business
289 model (G 2.1u)
290 Hypothesis 10 (H10). ... The agreement that to apply the CE, it is enough to use the existing
291 business models, reinforcing the reduction of consumption and energy, recycling, and recovery (G
292 3i).
293 Hypothesis 11 (H11). ... The agreement that the application of the CE requires the adoption of
294 new business models (based on recycling, reuse, recovery and on eco-design, eco-innovation, the use
295 of "closed" cycles and cooperation along the value chain) to be successful (G. 3j).
296

297 **4. Results**

298 The results are presented and discussed in this section, starting with the social-demographical
299 characteristics of the sample (subsection 4.1), followed by the descriptive statistics (subsection 4.2)
300 and ending with presentation and discussion of the statistical tests carried out for the validation of
301 the hypotheses (subsection 4.3).

302 **4.1. Social-demographical characteristics of the sample**

303 The survey yielded a total of 99 valid responses (5% response rate) and the more industrialized
304 northern region of Portugal accounted for more than a half of the total responses, with all regions
305 encompassing the sample, as presented in Figure 1.



306 **Figure 1.** Administrative area of the organization headquarters - (G 1.1.1))
307

308 As shown in Figure 2, a great deal of respondent organizations operates in the Business to
309 Business market (82%), followed by Business to Consumer (B2C) with 16%. Consistently with these
310 results, Industry is the main represented activity sector (56%) followed by services (17%), as depicted
311 in Figure 3.

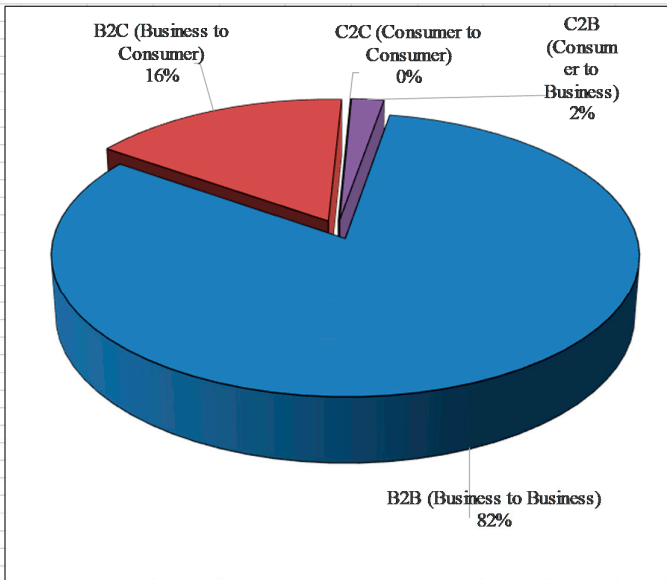


Figure 2. Market in which the organization operates (G 1.2)

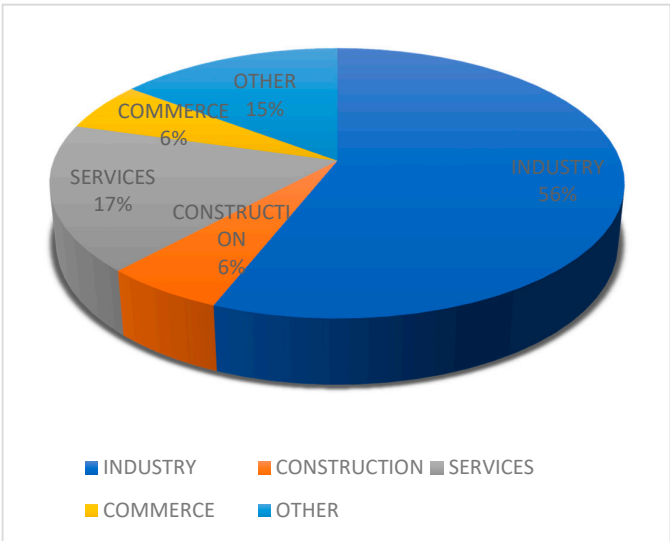


Figure 3. Activity sector where the organization operates (G 1.3)

326 Concerning the organizations size, Small and Medium Enterprises (SMEs) accounted for the
327 majority of respondents in accordance with the industrial Portuguese population. The distribution of
328 the organizations (percentage) breakdown by number of employees is presented in Figure 4.

329

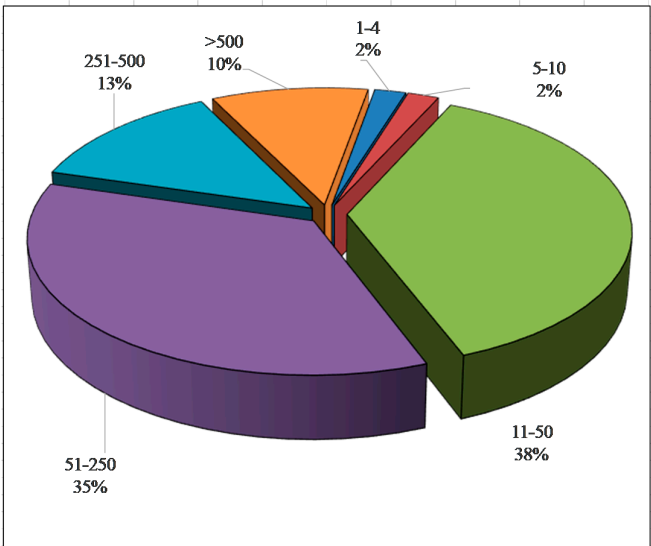


Figure 4. Dimension of the organization (N° of employees – G 1.5)

Relating to the implementation and certification of Environmental Management Systems (ISO 14001) 42% of the respondents hold a certified EMS for more than 3 years, 17% hold an implemented EMS without certification but 40% report not holding an implemented EMS, which is an indicator that there is still considerable work to be done in that regard (Figure 5).

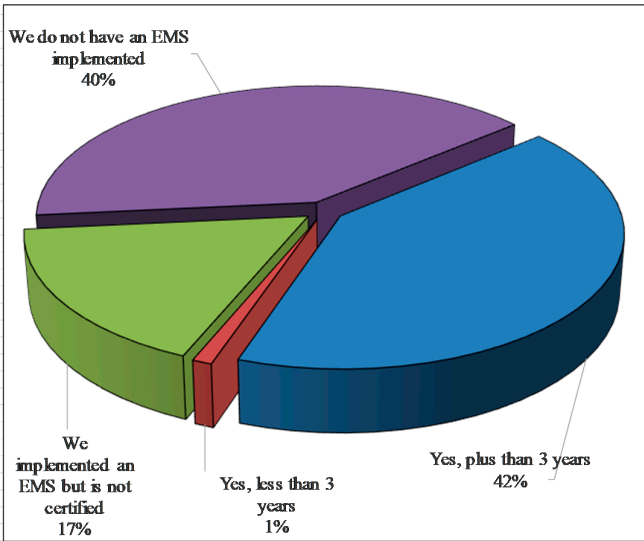
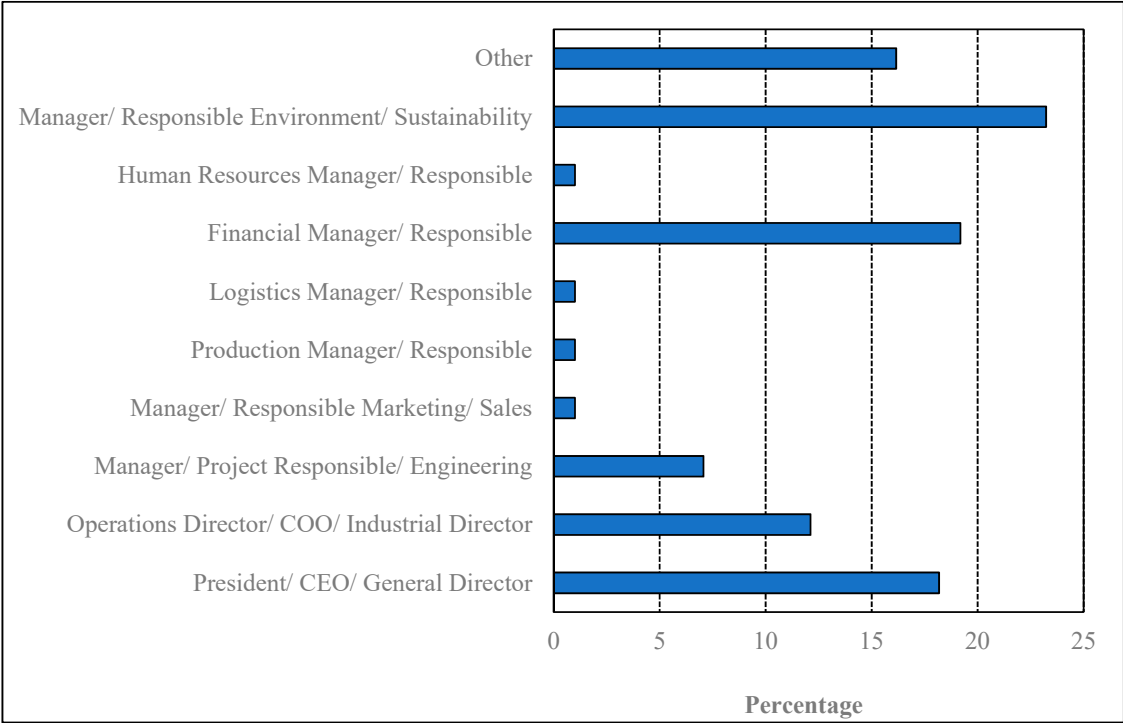


Figure 5. Status and maturity of the Environmental Management System - EMS (G 1.6))

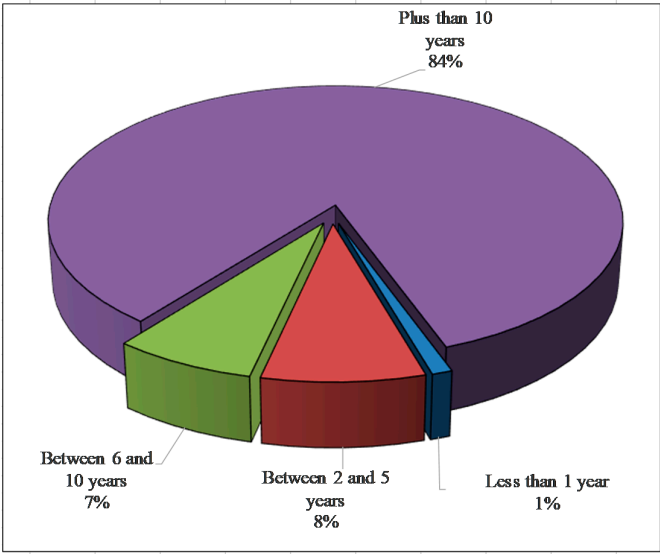
Concerning the individual respondents, 23% were Managers/ responsible of the Environment/ Sustainability, followed by 19% CFO (chief financial officer) and 18% CEO/COO (chief executive officer/ chief operating officer), which might indicate that the C suite is paying a growing attention to the environment and sustainability (see Figure 6). The respondents had considerable experience of the organization, with 84% working there for 10 or more years (Figure 7).

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Figure 6. Organizational role of the respondent in %(G 4.1)



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Figure 7. Experience of the respondent in the organization- Breakdown by number of years (4.2)

369 4.2. Descriptive Statistics

370 The surveyed organizations aim to fulfill their customers' demands in a proactive way, achieved
371 a price/quality compromise, and have established collaborative and value-added networks with their

partners and customers. They also focus on the efficient usage of energy and the reduction of raw materials and energy, however, the replacement of products by services and the collection and reuse of consumer products is fairly low, as is the case with the development of digital platforms to buy and sell products. Concerning the adoption of water, chemical products, and energy closed loops the reported results show an average intensity, with some variation within the respondents.

The overall results for these dimensions are presented in Table 2 and Figure 8.

Table 2. Level of strategy applicability (G 1.7a to G 1.7j)

Variable	Description	Mean	Standard Deviation
G 1.7.a	We are a large scale (volume) producer to be competitive with low price	2.61	1.12
G. 1.7.b	We focus on the efficient use and reduction of raw materials and energy consumption	3.81	0.97
G 1.7.c	We adopt water, chemical products and energy closed loops	2.94	1.14
G 1.7.d	We have a product performance and branding competitive advantage	3.81	0.90
G 1.7.e	We design products with a long-life utilization (increased value and endurance)	3.68	1.05
G 1.7.f	We replaced products by services and we support the collection and reuse of used consumer products	2.32	1.17
G 1.7.g	We developed digital platforms to buy and sell products	2.32	1.23
G 1.7.h	We achieved a price/quality compromise	3.98	0.65
G 1.7.i	We fulfill our customers demand in a proactive way	4.20	0.61
G 1.7.j	We established collaborative and value-added networks with our partners and customers	3.98	0.78

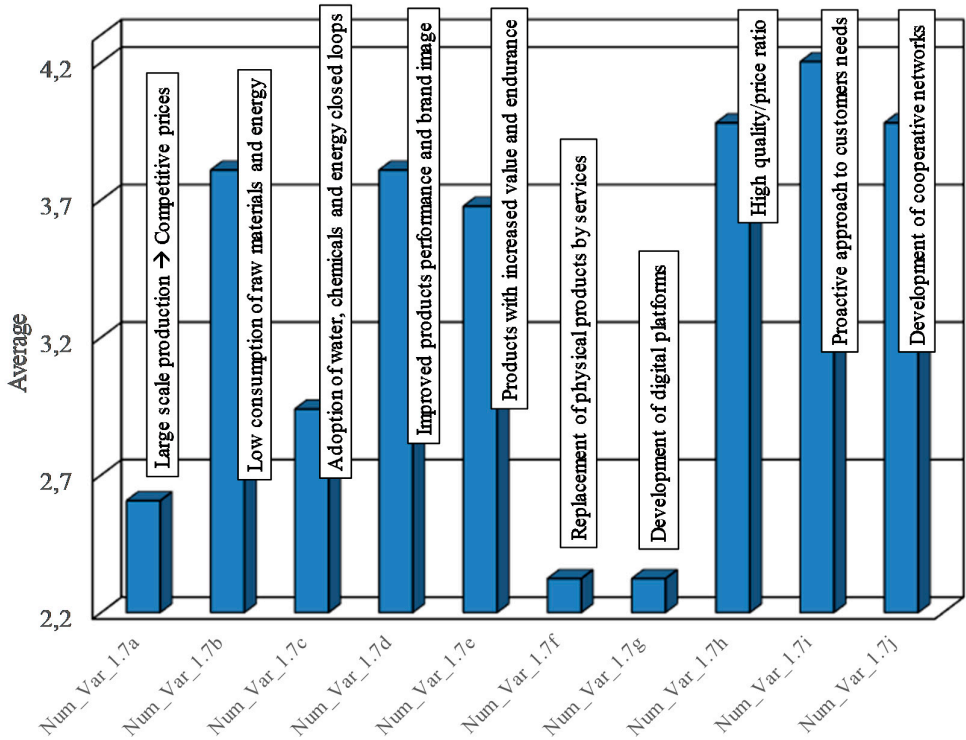


Figure 8. Level of strategy applicability (G 1.7a to G 1.7j)

Concerning the motivations driving organization towards CE adoption, the sampled organizations aim at improve their profitability, environmental performance, and environmental value creation. Additionally aim at acquiring new competencies, accessing novel markets and consumers, and developing a sustainable business model. Results suggest the absence of extensive external pressures to adopt CE and a limited legal and fiscal knowledge concerning CE. The actual application of CE projects in the reported organization is somehow limited. The descriptive statistics for the motivations, the knowledge and the level of application of CE are presented in Table 3 and Figure 9.

391

392 **Table 3.** Level of Motivations for CE (G 2.1a to G 2.1i), CE Knowledge (G 2.1j to G 2.1n) and CE
393 applicability in the organization (G 2.1n to G 2.1u)

Variable	Description	Mean	Standard Deviation
G 2.1a	Circular Economy (CE) helps us to reduce costs	3.58	0.88
G. 2.1b	The market is changing towards CE and we want to seize that opportunity	3.47	0.86
G 2.1c	We want to improve our environmental performance and create environmental value	4.06	0.70
G 2.1d	We want to have a better access to raw materials to prevent its scarcity	3.95	0.77
G 2.1e	We want to improve our profitability	4.35	0.63
G 2.1f	We want to acquire new competencies	4.11	0.74
G 2.1g	We have external pressures to adopt CE	2.61	1.09
G 2.1h	We want to have access to novel markets and consumers	4.06	0.83
G 2.1i	We want to have a sustainable business model	4.32	0.65
G 2.1j	We have the necessary legal (juridical) knowledge concerning CE	2.73	1.00
G. 2.1k	We have the necessary fiscal (tax) knowledge concerning CE	2.86	0.99
G 2.1l	We have the necessary technical knowledge concerning CE	3.04	0.95
G 2.1m	We have the necessary organizational knowledge concerning CE	2.97	0.95
G 2.1n	We know how to finance ourselves (funding) for the CE	2.82	0.95
G 2.1o	We do not develop any activities related to the CE	2.39	1.12
G. 2.1p	We are studying the CE and pondering what to do	3.05	1.11
G 2.1q	We plan to develop activities related to the CE	3.13	1.04
G 2.1r	We are carrying out a pilot project in the CE	2.38	1.16
G 2.1s	We are carrying out projects related to the CE for at least 1 year	2.63	1.17
G 2.1t	We are carrying out projects related to the CE for at least 3 years	2.49	1.18
G 2.1u	The CE is embedded in our business model	2.96	1.05

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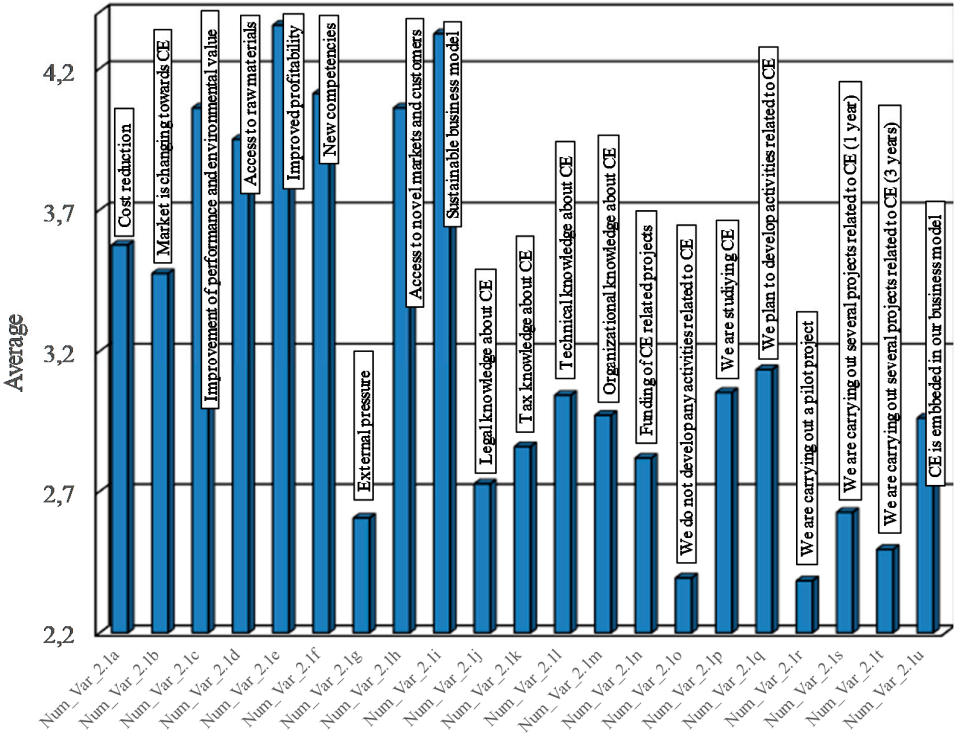


Figure 9. Level of Motivations for CE (G 2.1a to G 2.1i), CE Knowledge (G 2.1j to G 2.1m) and CE applicability in the organization (G 2.1n to G 2.1u)

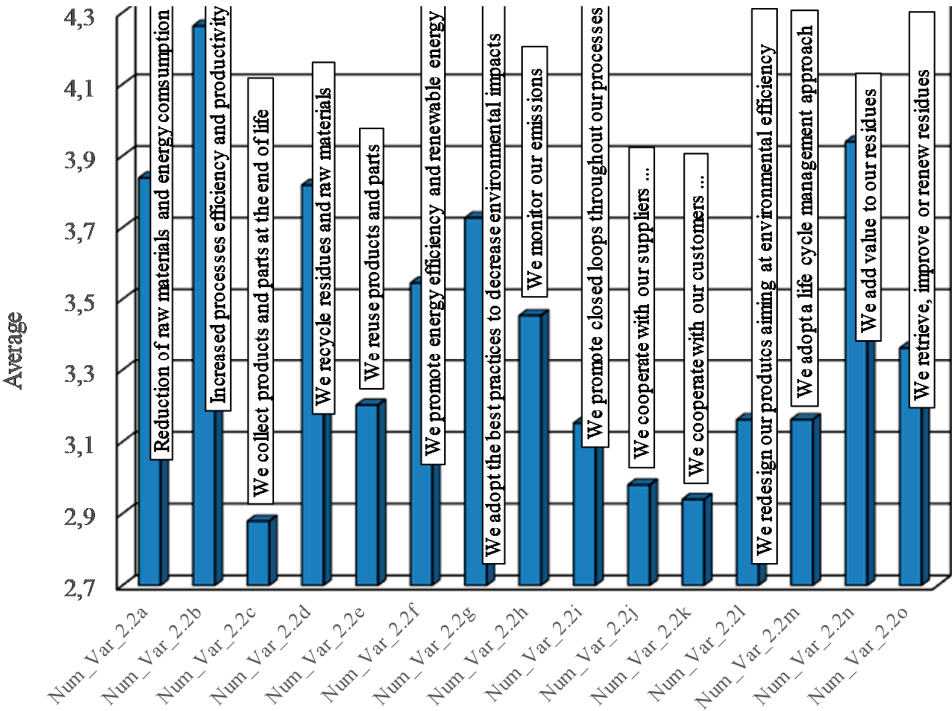
The improvement of the productivity and efficiency of the processes, and the segregation and valuation of waste are a priority, however, the collection of end-of-life products and the cooperation with suppliers and customers to establish closed loops that maximize the utilization of resources and minimize waste and environmental impacts is not very intense. The results suggest that the reuse of products and parts and the adoption of the life cycle approach are gaining momentum, within the surveyed organization. Table 4 and Figure 10 present the overall descriptive statistics for the application of the CE dimensions.

Table 4. Level of CE intensity on the organization (G 2.2a to G 2.2o)

Variable	Description	Mean	Standard Deviation
G 2.2a	We work on the reduction of raw materials and energy consumption	3.84	0.90
G 2.2b	We promote the improvement of the productivity and efficiency of our processes	4.26	0.63
G 2.2c	We collect end-of-life products and parts	2.88	1.38
G 2.2d	We recycle waste (residues) and raw materials	3.82	1.05
G 2.2e	We reuse (used) products and parts	3.20	1.10
G 2.2f	We promote energy efficiency and the use of renewable energy	3.55	1.02
G 2.2g	We adopt the best technologies and practices to reduce the environmental impacts of our processes and products	3.73	0.95
G 2.2h	We monitor our emissions, set targets, and implement actions to achieve them	3.45	1.23

G 2.2i	Our processes use closed loops, eliminating leaks and waste and minimizing the need for more raw materials and energy	3.15	1.06
G 2.2j	We cooperate with our suppliers to establish closed loops that maximize the utilization of resources and minimize waste and environmental impacts	2.98	1.08
G 2.2k	We cooperate with our customers to establish closed loops that maximize resource utilization and minimize waste and environmental impacts	2.94	1.03
G 2.2l	We redesign our products aiming at environmental efficiency and increased durability	3.16	1.06
G 2.2m	We adopt the lifecycle management approach	3.16	1.09
G 2.2n	We segregate and value our waste (residues)	3.94	0.95
G 2.2o	We retrieve (recover), improve, or renew used materials, products, or parts (residues)	3.36	1.07

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Figure 10. Level of CE intensity on the organization – (G 2.2a to G 2.2o)

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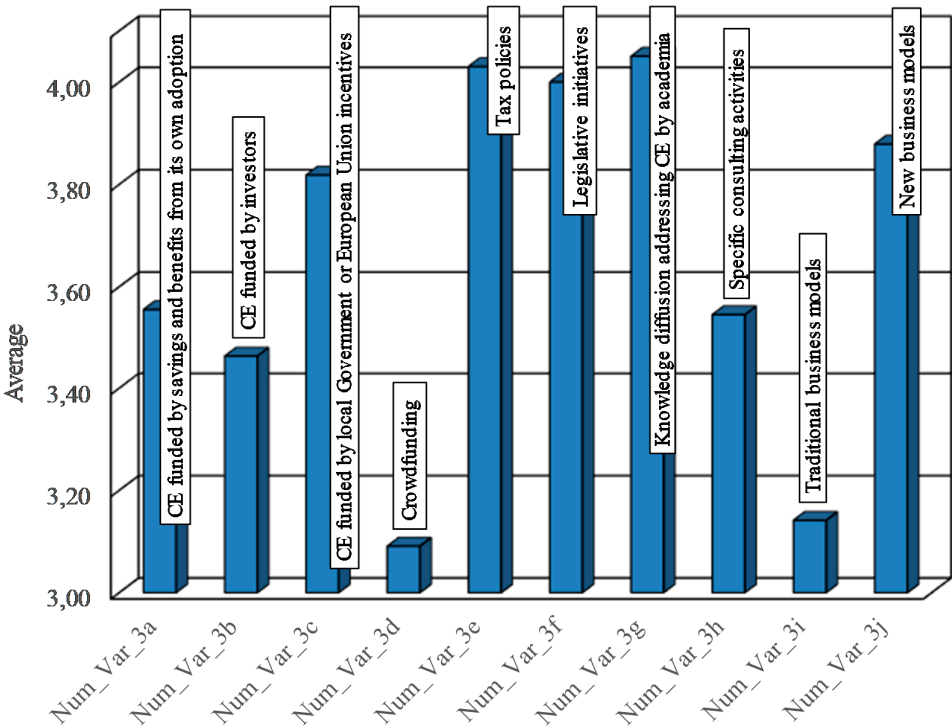
The respondents consider that tax (fiscal) policy should positively discriminate the organizations that work in the CE, that the Government should take legislative initiatives to support the CE and that Academia should focus on the dissemination and creation of knowledge in the CE. The availability of Government / European Union funding (incentive systems) is also important to finance the CE. One key aspect that is emerging is that the application of the CE “requires the adoption of new business models (based on recycling, reuse, recovery and on eco-design, eco-innovation, the use of “closed” cycles and cooperation throughout the value chain) to be successful”. An increased amount of respondents support this view when compared with those that consider the “existing (traditional) business models as sufficient to support CE”. The descriptive statistics for the level of agreement of the actions to support CE are shown in Table 5 and Figure 11.

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Table 5. Level of agreement with actions to promote CE (G 3a to G 3j)

Variable	Description	Mean	Standard Deviation
G 3a	The Circular Economy (CE) can be financed through the organizations' own savings and benefits with their application	3.56	0.66
G 3b	The funding (support) from investors is very important to finance the CE	3.46	0.72
G 3c	The Government / European Union funding (incentive systems) are very important to finance the CE	3.82	0.71
G 3d	Crowdfunding is very important to finance the CE	3.09	0,4
G 3e	Tax (fiscal) policy should positively discriminate the organizations that work in the CE	4.03	0.69
G 3f	The Government should take legislative initiatives to support the CE	4.00	0.73
G 3g	Academia should focus on the dissemination and creation of knowledge in the CE	4.05	0.64
G 3h	Specialized Ce consultancy CE is needed	3.55	0.64
G 3i	To apply the CE, it is enough to use existing (traditional) business models, reinforcing the reduction of consumption and energy, recycling, and recovery	3.14	0.78
G 3j	The application of the CE requires the adoption of new business models (based on recycling, reuse, recovery and on eco-design, eco-innovation, the use of "closed" cycles and cooperation along the value chain) to be successful	3.88	0.73

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Figure 11. Level of agreement with actions to promote CE (G 3a to G 3j)

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4.3. Statistical Tests

428 The Kolmogorov–Smirnov and the Shapiro–Wilk statistical tests were adopted to evaluate the
429 normality of the distribution of the results collected (Table 6) and decide the tests to be carried out
430 for the research questions. The statistical tests show that the results did not have a normal distribution
431 (Sigma ≤ 0.05) and therefore, the Kruskal–Wallis statistical test was adopted to ascertain and validate
432 the statistical hypotheses formulated.
433
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Table 6. Normality tests (Kolmogorov–Smirnov and Shapiro–Wilk).

Kolmogorov-Smirnov ^a				Shapiro-Wilk		
	Statistic	df ^b	Sigma	Statistic	df	Sigma
Num_Var_1.7a	0.193	99	0.000	0.904	99	0.000
Num_Var_1.7b	0.225			0.872		
Num_Var_1.7c	0.178			0.917		
Num_Var_1.7d	0.332			0.818		
Num_Var_1.7e	0.298			0.848		
Num_Var_1.7f	0.245			0.868		
Num_Var_1.7g	0.230			0.857		
Num_Var_1.7h	0.310			0.799		
Num_Var_1.7i	0.328			0.762		
Num_Var_1.7j	0.318			0.806		
Num_Var_2.1a	0.220			0.875		
Num_Var_2.1b	0.245			0.853		
Num_Var_2.1c	0.273			0.816		
Num_Var_2.1d	0.324			0.783		
Num_Var_2.1e	0.289			0.746		
Num_Var_2.1f	0.259			0.821		
Num_Var_2.1g	0.177			0.907		
Num_Var_2.1h	0.309			0.794		
Num_Var_2.1i	0.276			0.764		
Num_Var_2.1j	0.224			0.903		
Num_Var_2.1k	0.234			0.903		
Num_Var_2.1l	0.254			0.887		
Num_Var_2.1m	0.220			0.903		
Num_Var_2.1n	0.253			0.881		
Num_Var_2.1o	0.172			0.888		
Num_Var_2.1p	0.189			0.905		
Num_Var_2.1q	0.207			0.902		
Num_Var_2.1r	0.177			0.884		
Num_Var_2.1s	0.189			0.907		
Num_Var_2.1t	0.208			0.895		
Num_Var_2.1u	0.202			0.913		
Num_Var_3a	0.296			0.806		
Num_Var_3b	0.257			0.828		
Num_Var_3c	0.309			0.824		
Num_Var_3d	0.296			0.845		
Num_Var_3e	0.281			0.816		
Num_Var_3f	0.258			0.828		
Num_Var_3g	0.299			0.787		
Num_Var_3h	0.285			0.797		
Num_Var_3i	0.279			0.861		
Num_Var_3j	0.232			0.804		

a. Lilliefors Significance Correction; b. Degrees of freedom

435

436 In order to validate the research hypotheses the following criteria was adopted per dimension:
437 - Hypothesis validated (✓): at least 2/3 of the items tested validated according to the Kruskal–
438 Wallis test (p-value <0.05).
439 - Hypothesis partially validated: More than 1/3 and less than 2/3 of the items tested validated
440 according to the Kruskal–Wallis test (p-value <0.05).

- Hypothesis rejected (✖): Less than 1/3 of the items tested validated according to the Kruskal-Wallis test (p-value<0,05).

Tables 7 and 8 present the results from the Kruskal–Wallis statistical test (Asymptotic Sigma). The results concerning the Dimension 1 (Table 9) suggest that the definition of strategic goals and policies in the organization do not differ according to the market or activity sector in which the organization operates (H1 and H2 rejected). Additionally, based on the statistical test carried out, the results do not statistically differ according to the dimension of the organization (H3 rejected) or according to the organizational role of the respondent (H5 rejected). On the other hand, results suggest that the status and maturity (years) of the EMS certification do impact on the definition of strategic goals and policies in the organization (H4 accepted).

Table 7. Chi-Square statistic and Asym. Sig. (Kruskal-Wallis test)- Dimension 1

		Num_Var (Grouping variable)									
		1.2		1.3		1.5		1.6		4.1	
		Statistic	Asym. Sig.	Statistic	Asym. Sig.	Statistic	Asym. Sig.	Statistic	Asym. Sig.	Statistic	Asym. Sig.
Num_Var (Tested variable)	2.1c	0,038	0,981	12,600	0,558	10,667	0,058*	21,079	0,000***	15,2	0,125
	2.1d	0,211	0,900	27,199	0,018**	6,288	0,279	4,447	0,217	14,638	0,146
	2.1i	0,892	0,606	14,566	0,408	5,29	0,382	10,114	0,018**	27,334	0,002**
	2.1u	1,021	0,600	14,440	0,417	14,277	0,014**	14,041	0,003**	7,973	0,631
	3i	7,031	0,030**	13,516	0,486	3,583	0,611	0,443	0,931	7,484	0,679
	3j	0,105	0,949	20,595	0,112	8,853	0,115	9,918	0,019**	16,033	0,099*

* Statistical significant at 0.1 level; ** Statistical significant at 0.05 level; *** Statistical significant at all levels

Regarding dimension 2, the level of CE intensity in the organizations seem to be impacted by the willingness of the organizations to improve the environmental performance and create environmental value (H6 accepted), willingness to have a better access to raw materials to prevent its scarcity (H7 accepted), the willingness to have a sustainable business model dimension of the organization (H8 accepted) and the agreement that CE is an integral part of the organizational business model (H9 accepted). On the other hand, the agreement that to apply the CE, it is enough to be supported by the existing business models, reinforcing the reduction of consumption and energy, recycling, and recovery (H10) and the agreement that the application of the CE requires the adoption of new business models (based on recycling, reuse, recovery and on eco-design, eco-innovation, the use of "closed" cycles and cooperation along the value chain) to be successful (H11) seem not to impact on the CE intensity in organizations (H10 and H11 rejected).

Table 8. Chi-Square statistic and Asym. Sig. (Kruskal-Wallis test)- Dimension 2

		Num_Var (Grouping variable)											
		2.1c		2.1d		2.1i		2.1u		3i		3j	
		Statistic	Asym. Sig.	Statistic	Asym. Sig.	Statistic	Asym. Sig.	Statistic	Asym. Sig.	Statistic	Asym. Sig.	Statistic	Asym. Sig.
Num_Var (Tested variable)	2.2a	20,856	0,000***	30,989	0,000***	14,649	0,002**	14,358	0,006**	2,668	0,615	5,55	0,062*
	2.2b	30,89	0,000***	36,893	0,000***	25,171	0,000***	19,535	0,001**	2,327	0,676	11,256	0,004**
	2.2c	6,26	0,100	3,642	0,457	6,433	0,092*	13,295	0,010**	1,764	0,779	3,221	0,200
	2.2d	7,989	0,046**	17,564	0,002**	12,262	0,007**	9,977	0,041**	2,439	0,656	1,313	0,519
	2.2e	9,357	0,025**	17,447	0,002**	5,528	0,137	12,749	0,013**	3,11	0,540	1,832	0,400
	2.2f	14,034	0,003**	13,33	0,010**	8,736	0,033**	7,649	0,105	5,201	0,267	11,761	0,003**
	2.2g	20,567	0,000***	21,588	0,000***	14,487	0,002**	25,249	0,000***	2,512	0,643	8,206	0,017**
	2.2h	25,473	0,000***	15,658	0,004**	14,988	0,002**	14,945	0,005**	6,317	0,177	6,831	0,033**

	2.2i	14,922	0,002**	20,959	0,000***	8,851	0,031**	29,715	0,000***	3,911	0,418	0,918	0,632
	2.2j	9,879	0,020**	18,421	0,001**	6,859	0,077*	20,781	0,000***	4,466	0,347	0,109	0,947
	2.2k	7,71	0,052*	9,081	0,059*	6,619	0,085*	19,779	0,001**	5,136	0,274	0,369	0,832
	2.2l	19,079	0,000***	17,977	0,001**	14,173	0,003**	14,272	0,006**	0,245	0,993	5,773	0,056*
	2.2m	13,339	0,004**	17,582	0,001**	13,66	0,003**	18,091	0,001**	0,823	0,935	3,168	0,205
	2.2n	15,014	0,002**	19,931	0,001**	20,302	0,000***	16,268	0,003**	3,951	0,413	7,135	0,028**
	2.2o	8,403	0,038*	16,93	0,002**	11,272	0,010**	13,354	0,010**	4,494	0,343	0,927	0,629

* Statistical significant at 0.1 level; ** Statistical significant at 0.05 level; *** Statistical significant at all levels

Table 9 summarizes the validation of the several research hypotheses raised and pertinent to this research.

Table 9. Validity of the research hypotheses.

Dimension	Research Hypotheses	Validity	Comment
Organizational goals and strategies: G 2.1c; G 2.1d; G 2.1i; G 2.1u, G 3i and G 3j	H1	✗	...market in which the organization operates.
	H2	✗	...activity sector where the organization operates.
	H3	✗	...dimension of the organization (N° of employees).
	H4	✓	...status of EMS certification.
	H5	✗	...organizational role of the respondent.
Level of CE intensity (G 2.2a to G 2.2o)	H6	✓	...willingness to improve the environmental performance and create environmental value (G 2.1.c).
	H7	✓	...willingness to have a better access to raw materials to prevent its scarcity activity sector where the organization operates (G 2.1.d).
	H8	✓	...willingness to have a sustainable business model dimension of the organization (G 2.1.i).
	H9	✓	...the agreement that CE is an integral part of the organizational business model (G 2.1.u).
	H10	✗	...the agreement that to apply the CE, it is enough to use the existing business models, reinforcing the reduction of consumption and energy, recycling, and recovery (G 3.i).
	H11	✗	...the agreement that the application of the CE requires the adoption of new business models (based on recycling, reuse, recovery and on eco-design, eco-innovation, the adoption of "closed" cycles and cooperation along the value chain) to be successful (G. 3.j).

5. Conclusions

This study has enabled us to map the motivations and potential actions to promote CE and the actual level of its application within a sample of 99 Portuguese organizations, from a wide range of activity sectors and with diverse sizes. Although the low response rate collected in a single country advises using some caution to generalize the results, several interesting conclusions can be highlighted.

In terms of the function of the individual respondents, they were highly experienced (84% with more than 10 years working experience on their organization) and more than 30% come from the so-called C suite (President, CEO-Chief Executive Officers, COO-Chief Operations Officer). They were followed by 23% of Managers/responsible for the environment/sustainability and 19% Financial Managers (CFO). This is an indication that CE is regarded as a strategic and relevant issue for the organization profitability and value creation, not just a technical one to incrementally improve

environmental performance. This is a considerably higher value for Top Managers respondents than those reported in a similar research addressing ISO 14001 EMS implementation [32] and taking into consideration the relevance of the company culture for the success of CE [24, 35] it is a prospective indicator of more intense CE application in the future.

Strategically, the surveyed organizations report to be very customer oriented and to adopt a differentiation or value for money strategy (high quality/price ratio), rather than being low price competitive and volume large-scale producers. This is an option that is consistent with the small size of the organizations and suggests that CE can be aligned with the companies search for innovative and performant processes, products, and solutions. The efficient management of energy and the reduction of raw materials consumption is a clear strategic option, as it can output both positive economic (fewer costs) and environmental (lesser impact and pollution) outcomes, which is consistent with the conclusions from previous studies [13, 15, 19]. However, the adoption of water, chemical products and energy closed loops show medium results (with some variation) and the collection and reuse of products is not very high. The replacement of products by services and the development of digital platforms to sell their products is also low, which might partly explain since most of the organizations are SMEs within the global supply chain and have limited bargaining power, and most operate in Business to Business (B2B) market and not in the Business to Consumer (B2C) one. A positive indication is the establishment of collaborative and value-added networks with the organization partners which is a major CE enabler reported in the literature [33, 36, 39].

Concerning the motivations for the adoption of CE, there is a strong indication that the surveyed organizations aim at a sustainable business model and improve both, their profitability and value creation, and their environmental performance. They aim at acquiring new competencies and access novel markets and consumers, which is relevant to achieve a sustainable business model and enduring value creation. However, the organizations do not report many external pressures to adopt CE suggesting that supply chain partners and consumers still do not demand for “green suppliers” and “green products”, which has been reported as a major obstacle for CE adoption in previous researches [24, 36, 39, 40] and might indicate a resistance from powerful supply chain actors and consumer preferences, towards CE.

Concerning the level of application of CE in the surveyed organizations, the improvement of the productivity and the efficiency of the organizations' processes, are the main priorities. The segregation and valuation of waste is a priority, however, the collection of end-of-life products and the cooperation with suppliers and customers to establish closed loops that maximize the utilization of resources and minimize waste and environmental impacts is not very intense. This is an indication that CE might still be perceived as the classic “reduce, reuse, and recycle” approach. From a more positive perspective, the reutilization of products and parts and the adoption of the life cycle approach are gaining momentum.

In respect to the actions to promote CE (enablers), the results are aligned with those reported in the literature. There is agreement that the tax (fiscal) policy should positively discriminate the organizations that work in the CE and that the Government should take legislative initiatives to support the CE, as reported in previous studies [25, 38]. “Finance engineering” for CE and the availability of Government / European Union funding (incentive systems) is also an important issue for the surveyed companies, which is consistent with previous studies that stressed the importance of funding to finance CE investments [24, 36, 41]. The level of agreement that the application of the CE “requires the adoption of new business models (based on recycling, reuse, recovery and on eco-design, eco-innovation, is higher than the level of support for considering the “existing (traditional) business models as sufficient to support CE”. This may indicate that the comprehension of CE is improving within Portuguese organizations. And finally, there is an agreement that Academia should focus on the dissemination and creation of knowledge in the CE, which is in line with previous studies that reported the need for a deeper understanding and knowledge on the benefits and application of CE [37].

Concerning the several research questions tested, the results suggest that the more mature EMS ISO 14001 certified organizations adopt different strategic goals and policies. Additionally,

organizations aiming at the improvement of the environmental performance and create environmental value, to have a better access to raw materials to prevent its scarcity and to have a sustainable business model, show a higher level of CE intensity. The consideration that CE is an integral part of the organizational business model is also relevant for a higher CE adoption level. These results are consistent with the conclusions of Jonkers et al. [33] research among Dutch companies.

In a “nutshell” the concept of CE is supported by Portuguese organizations' and the results show that CE is regarded as a strategic and relevant issue for the organizations profitability and value creation. The perception that it requires the adoption of new business models in addition to the classical “reduce, reuse, and recycle” approach is growing which might be a possible outcome of the EU, Portuguese Government, business, and society at large, actions to promote CE [26, 28, 45, 46]. Moreover, the potential for CE may be enhanced through an integrated approach considering other dimensions that impact on the organizational performance such as Quality and Occupational Health and Safety [47]. The results of the hypotheses tests indicate that the EMS certification and related maturity and the willingness to improve the environmental performance and operate through a sustainable business model have significant positive impacts on the level of CE adoption.

The study also shows how companies struggle with the design of the CE in a dominant linear environment and that its activities are still presently relatively modest. It is recognized that CE has the potential to produce new revenue models, but organizations claim the need for a friendlier institutional environment (fiscal, legal, organizational, etc.) that helps to promote the CE and the search for increased forms of cooperation. To that aim, possible policy areas could address the increase of reuse, repair and remanufacturing, the promotion of green public procurement and innovation procurement, and the development of secondary materials markets [48].

As an overall conclusion, it is highlighted the relevance of adopting production systems based on less intensive materials use and that promote materials and products reuse and/or recycling. Collaboration practices and government actions to promote CE should also be fostered. Value creation is no longer about making as many items as possible, but about the optimization of the materials through the full product life-cycle and the improvement of the overall economic, environmental, and social performance in a balanced, holistic and systemic way. Organizations also need to address CE with a strategic view, adopt the right business and revenue models and properly monitor its economic, environmental, and social performance.

These results are valuable for both policymakers and business actors as they aim to promote and benefit from the adoption of CE business models and practices. As suggestion for future research it is not yet clear how the transition from a linear to a circular economy can be shaped and who (market or government) will lead the transformation. It is not evident how companies will address CE issues with external parties (e.g. how are things mutually agreed?) and the fact that a positive attitude towards CE does not mean that a lot has changed in the business activities. Moreover, CE is not just to increase recycling, but a fundamentally different way of organizing the economy based on cooperative networks and the preservation of raw materials, semi-finished products, and products. The research into the organizational aspects of the CE and the replication of this investigation in other countries (such as Poland and Slovakia), are avenues to pursue.

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Conflicts of Interest: The authors declare no conflict of interest

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