Development and validation of a tool for the integration of the Circular Economy in industrial companies: Case study of 30 companies.

Idoia Urain[a,*], José Alberto Eguren[a], Daniel Justel[a]

[a] Mondragon Unibertsitatea, Mechanics and Industrial Production, Faculty of Engineering, Mondragon Unibertsitatea, Loramendi 4, Mondragon 20500 Gipuzkoa, Spain

Corresponding author (*): iurain@mondragon.edu

Abstract

Circular Economy (CE) implementation is considered an instrumental strategy to help reaching the world´s resource, energy, and climate mitigation targets, including the Sustainable Development Goals (SDGs) 2030. However, major barriers must be overcome to facilitate CE implementation in industry such as cultural, market, regulatory and technological considerantions (Kirchherr et al., 2018). Improving management systems within industrial companies is crucial when implementing effective CE solutions in compliance with existing industrial standards such as quality and environmental management systems. However, it is not yet common practice yet due to the lack of standardized, suitable, and easy-to-use supporting analytical tools. This paper attempts to fill this gap by presenting Industrial Circular Economy Questionnaire *(ICEQ)*, a self-diagnosis questionnaire built upon the revision of industrial harmonized standards and, academic literature on business-level CE assessment tools. *ICEQ*, compiling a set of 165 questions for company self-CE assessment, was applied to 30 industrial companies belonging to 17 economic sectors (automotive, machining and metalworking transformation, waste management, machine tool, etc.) in the Basque Autonomous Community (BAC) in Spain. The automotive sector stands out with 70% of circularity while Machining and metalworking transformation only has 34%, showing that the automotive sector is more conscious of CE since they must comply with End-of-Life Vehicles (EoLV) legislation.

Keywords: Circularity performance, environmental sustainability, resource efficiency, survey, circular economy, industrial company.

1. Introduction

Linear economy has become inefficient in its use of resources and waste generation, causing significant environmental and socio-economic impacts (Sariatli, 2017). The Circularity Gap Report (Circle Economy, 2021) shows the magnitude of the problem, presenting among other things: i) the increase of temperature (3 to 6 degrees), ii) the greenhouse gas emission (we will emit 65 billion tones in 2030), and iii) the circularity of the world economy which in 2020 was 8,6% (0,5% less than two years earlier) knowing that the majority (70%) of emissions are associated with material handling and use. It also emphasizes that global warming shows no signs of slowing down and can cause catastrophes that threaten the population. In an attempt to reverse these trends, the European Commission (EC) adopted in 2015 an action plan for the deployment of a Circular Economy (CE) to boost employment, growth, and investment and develop a competitive, carbon-neutral, and resource-efficient economy (European Commission, 2015). This action plan was later followed up by the Green Deal, which highlighted that CE is required to stimulate the development of lead neutral and circular products markets, including a “sustainable products” policy (European Commission, 2019). This aims to make Europe the first climate-neutral continent by 2050, trying to achieve a clean and zero emission CE (European Commission, 2019) .

Ellen MacArthur Foundation (2017) defines CE as “a systemic approach to economic development designed to benefit businesses, society, and the environment” based on three principles (Ellen Macathur Foundation, 2015): i) preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows, ii) optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles, and iii) foster system effectiveness by revealing and designing out negative externalities. Accordingly, CE can be operationalized through the development of four major strategies (Bocken et al., 2016); i) narrow resource loops, which engender less resource usage per unit of product/service (Bocken et al., 2017), ii) slow resource loops, which refers to intensifying their use throughout the production and consumption system, iii) close resource loops, which imply closing the life cycle of materials through efficient collection, material recovery and recycling systems, and iv) regenerate resource loops, which refers to a shift towards the use of non-toxic substances and renewable materials and energy (Konietzko et al., 2020). Finally, the strategies mentioned above can be deployed through the implementation of the so-called 10Rs of CE (Blomsma et al., 2019; Potting et al., 2017): refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover. These CE solutions can be implemented on four levels (Saidani et al., 2017): i) macro, referring to regions, countries, and cities, ii) meso, to economic sectors and industrial parks, iii) micro, encompassing business models and organizations, and iv) nano, to product, service, or business unit.

Industrial companies are key players in the delivery of the CE agenda. These can greatly influence the way resources are consumed and managed, through innovation of product, business strategy reorientation, business model redesign or value chain reconfiguration (Geissdoerfer et al., 2017). However, there are several internal and external barriers that hinder such a transition to a more circular model, including cultural, market, regulatory and technological barriers (Kirchherr et al., 2018). Nevertheless, for companies to start implementing CE, it is important to integrate the principles at the operational level (micro level), which includes: i) reconfiguration of business models and ii) redesign of products and services (Rocha et al., 2019). In this process, the use of harmonized CE standards and tools can play a key role.

A new diagnostic questionnaire has been created in which harmonized standards items, considered appropriate to meet the technical requirements of European legislation (European Union, 2021), are intertwined with CE strategies and solutions. This will provide more accurate results on the circularity of companies and being able to respond to both external and internal barriers that industrial companies may face. The goal is to present a comprehensive, self-improving, though user-friendly and versatile, CE questionnaire that can be used by industrial companies to determine their current circularity performance (maturity level). Accordingly, the paper is structured as follows: section 2 presents the research methodology, section 3 introduces the discussion and section 4 present the conclusions.

2. Methodology

A five-step methodology has been applied to develop Industrial Circular Economy Questionnaire *(ICEQ)* for industrial companies, as illustrated in Figure 1. The steps developed include:

i) *Literature review:* With the goal of developing a questionnaire that allows industrial organizations to analyze the circularity of their current business unit and integrate CE strategies and solutions into their business model. The following areas have been analyzed in order to implement integration: i) harmonized standards, ii) bibliographic review of CE diagnosis, and iii) CE diagnostic tools.

ii) *ICEQ development*: For the development of *ICEQ*, a 165 questions self-diagnosis questionnaire in which participants obtain results on the circularity of their company, the items of harmonized standards have been intertwined with the CE strategies and solutions and both questionnaires analyzed in the literature and those of the diagnostic tools have been used as examples to create a more complete questionnaire.

iii) *Application*: It has been applied in several industrial companies of the Basque Autonomous Community (BAC) in Spain, all of which vary in sector and size (Specifically it's been applied in 30 companies in 17 sectors).

iv) *Validation*: Once the questionnaire was completed, a small survey in the form of a semi-structured interview was carried out through workshops with the participating companies to find out their opinion regarding *ICEQ*.

v) *Evaluation and improvements*: Ensure that the questionnaire is useful and fulfills the objective. To this end, meetings have been held with companies and their feedbacks has been gathered in order to make the necessary changes .and improvements.

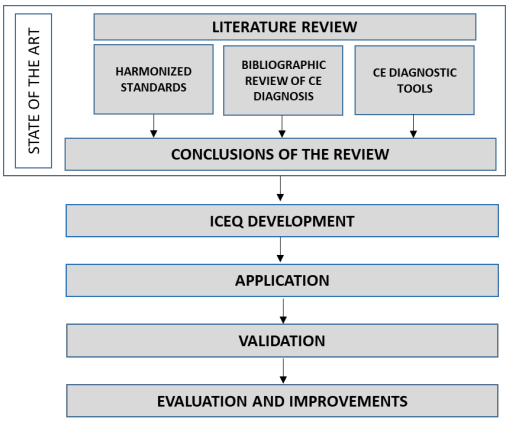

Figure 1: Research methodology

As Urbinati et al. (2020) have mentioned a multiple case study analysis allows us to analyze data: i) within each situation and ii) across situations. This methodology is useful to adopt for qualitative analyses and a theory-testing approach (Siggelkow, 2007; Yin, 2003). Case study research provides enriching data and is suitable for investigating processes that change over time (Bluhm et al., 2011) in which the improvements that participants have made can be seen. Multiple sources of evidence- in interviews, voice records, and documentation gathered during the sessions with the companies- were collected. This was to add breadth and depth to data collection and to contribute to the validity of the research (Eisenhardt, 1989).

The survey technique is widely used because it allows us to obtain data in a fast and efficient way (Casas Anguita et al., 2002). The development of the questionnaire has considered the unworked inputs, types of questions and answers and information identified in sections 3.1, 3.2 and 3.3, which are explained below.

3. Literature review

3.1 Harmonized standards

Management systems focus on continuous improvement and obtain a global view of the organization. To determine which specific aspects and items are important in an organization, standards are analyzed, and CE opportunities are identified. For the integration of CE in industrial companies, seven harmonized standards are identified as

the main ones (Table 1), the first four being management standards and the last two CE standards.

Table 1:Selected harmonized standards and the purpose

	Harmonized Standards	Objectives
Management systems	ISO 9001:2015- Quality management systems	Ensure that an organization achieves customer satisfaction through the establishment of continuous improvement processes (AENOR, 2015).
	ISO 14001:2015- Environmental management systems	Provide companies with a framework for environmental protection and respond to climatic conditions, balancing it with socio-economic needs (ISO 14001:2015, 2016).
	EMAS- Community Eco-Management and Audit Scheme	Promote continuous environmental improvement of organizations (EMAS, 2014).
	ISO 14006:2020- Environmental management systems	Promote environmental improvement focused on products and services, integrating it with management systems (Normas ISO, 2022).
	ISO 56002:2019- Innovation management systems	Guides the organization in determining its innovation vision, strategy, policy, and objectives (AENOR, 2020).
CE	BSI 8001:2017- Framework for the application of CE principles in organizations	Involve the main economic and social players in the transition towards a CE (BS 8001, 2017).
	XP X30-901:2018- CE project management system	Facilitate dialogues to reflect on modes of production and consumption and provide a management tool to plan, implement, evaluate, and improve a circular economy project (AFNOR, 2020).

This selection was made because of two reasons: i) are the most popular and commonly used by industrial companies (Horielikova, 2020), and ii) are the most closely aligned with the CE (Gabarró Sust, 2021). Of these standards mentioned, EMA was discarded, because companies tend to opt for ISO 14001:2015 (Merli & Preziosi, 2018).

Table 2 shows the grouping of all the items that each harmonized standard cites in relation to the company and marks with an "X" those that each one refers to. In order to contrast which of these items are used in the management standards and in the CE standards, thus being able to integrate CE in organizations without the need for new certifications. To identify all items, we read the standards and identified which aspects of the organization they value, dividing them into three large groups (external context, internal context, and stakeholders).

Moreover, most companies use quality management systems to be able to structure the company. According to Mintzberg, (1988) the organizational structure is the set of all the ways in which work is divided into different tasks, thus achieving coordination among all of them. Therefore, the ISO approach allows industrial companies to structure the whole company.

Table 2 therefore shows, on the one hand, that the CE vision can be integrated into the management standards used by industrial companies because, since there are items that both standards take into account (design and development, environment, customers, etc.), companies will not have to make very significant changes, but will have to consider aspects of CE that they do not currently work on and introduce them into their management.

On the other hand, to integrate BSI 8001:2017, CE into management standards it is necessary to add elements in the analysis. According to Legegunea (2019) the most used standards by companies in BAC are ISO 9001:2015 and ISO 14001:2015, and hence, can be a starting point to analyze how to integrate CE. That is why the rest of the standards have been discarded when carrying out this work; although this does not mean

that in the future the rest of the standards analyzed will be integrated to improve the process.

Table 2: Items for analysis of harmonized standards

Harmonized standards items			Management Systems				CE	
			9001	14001	14006	56002	BSI 8001	XP X 30-901
External context	Legislative		X	X	X	X	X	X
	Leadership	Politics	X	X	X	X		X
		Compromise	X	X	X	X		X
		Responsibilities	X	X	X	X		X
		Resources	X	X		X	X	X
		Competitor	X	X	X	X		X
	Support	Awareness	X	X		X		X
		Communication	X	X		X		X
		Marketing			X	X	X	
		Documented information	X	X	X	X	X	X
Internal context		Product/Service requirements	X		X			X
		Materials					X	
		Design and development	X		X	X	X	X
	Operations	Processes, products, and services supplied externally	X			X	X	X
		Production and service provision	X	X				X
		Product/Service release	X					X
		Control of non-conforming outputs	X		X	X		X
		Emergency response		X				
		Logistics/Reverse logistics					X	
	Technological		X				X	X
	Market		X			X		X
	Sociocultural		X			X		X
	Economical		X			X	X	X
	Environmental			X	X	X	X	X
Stakeholders	Clients		X		X	X		X
	Consumers				X		X	
	Supplier		X		X	X		X
	Partners		X			X		X
	Internal staff		X			X		X
	Competitors		X		X			X
	Administration		X					X

Therefore, it is a good strategy to approach CE in organizations from the structure of the two ISOs mentioned above. This is because BAC companies by having a fixed structure will know at all times how to move forward and adapt those changes that CE proposes to their business activities without many problems. Moreover, this structure will help to overcome barriers such as (Agyemang et al., 2019; Caldera et al., 2019; de Jesus & Mendonça, 2018; Kirchherr et al., 2018): i) lack of knowledge and capabilities, ii) financial resources, iii) organizational culture, iv) appropriate legislation and v) policies, among others. The reason that it is important to overcome these barriers is because it enables to the companies to integrate the CE principles at their operational level.

3.2 Bibliographic review of CE diagnosis

The review of questionnaires, surveys and diagnostic interviews of CE are conducted in a systematic manner. This methodology allows carrying out a search with a clear objective, a question, and a defined search approach that establishes inclusion and exclusion criteria and elaborates a qualitative evaluation of the articles (Jesson et al., 2011). To this end, the following steps were followed: i) location of the studies, and ii) selection and evaluation of the papers.

3.2.1 Locating studies, selection, and evaluation of work

The objective of the search was to find diagnostic tools that facilitate the implementation of the principles of CE, focusing on finding surveys in this field. Web of Science (WoS), and Scopus were selected as search engines, as they are considered the most comprehensive scientific databases (Aghaei Chadegani et al., 2013). The search string was as follows ("circular economy" OR "circularity") AND ("surve*" OR "questionnair*" OR "interview*").

The last search was carried out in September 2021, and all articles published in English between 2009-2021 were considered. No geographical restrictions were imposed, and a search was carried out on the title, keywords and abstract.

As a result, 674 articles were found on Scopus and 621 articles on WoS. For the final selection, duplicate articles were discarded, achieving a total of 771 combining both datasets. The search was filtered by analyzing titles, keywords, and abstracts and those that did not fit the scope were discarded. Following, a total of 63 articles were selected, and after a complete reading, 20 were discarded, attaining a total of 43 articles.

3.2.2 Literature analysis

Table 3 shows the 43 selected articles. Once all the questions were identified, a new table was created, which can be found in the supporting information document. The table was called *SP1. Articles from the harmonized standards Vs. Literature review questionnaire*. In this table *(SP1)*, a relationship was created between the article questions and items of the harmonized standards identified in Table 2.

Table 3: Selected articles to analyze the questionnaires

Authors	Article title
Kumar et al. (2019)	Circular economy in the manufacturing sector: benefits, opportunities, and barriers.
Masi et al. (2018)	Towards a more circular economy: exploring the awareness, practices, and barriers from a focal firm perspective.
Jakhar et al. (2019)	When stakeholder pressure drives the circular economy: Measuring the mediating role of innovation capabilities.
Bassi & Días (2019)	The use of circular economy practices in SMEs across the EU.
Piyathanavong et al. (2019)	The adoption of operational environmental sustainability approaches in the Thai manufacturing sector.
Milios et al. (2019)	Sailing towards a circular economy: Conditions for increased reuse and remanufacturing in the Scandinavian maritime sector.
Cristoni & Tonelli (2018)	Perceptions of Firms Participating in a Circular Economy.
Ceptureanu et al. (2018)	Perceptions of circular business models in SMEs.
Hopff et al. (2019)	New dimensions for circularity on campus-framework for the application of circular principles in campus development.
Katz-Gerro & López Sintas (2019)	Mapping circular economy activities in the European Union: Patterns of implementation and their correlates in small and medium-sized enterprises.
Zeng et al. (2017)	Institutional pressures, sustainable supply chain management, and circular economy capability: Empirical evidence from Chinese eco-industrial park firms.
Hojnik et al. (2017)	Eco-innovation and firm efficiency: Empirical evidence from Slovenia.
Fonseca et al. (2018)	Assessment of circular economy within Portuguese organizations.
Zhu et al. (2010)	Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications.
Ormazabal et al. (2018)	Circular Economy in Spanish SMEs: Challenges and opportunities.
Zhu, Geng, & Lai (2011)	Environmental supply chain cooperation and its effect on the circular economy practice-performance relationship among Chinese manufacturers.
Agyemang et al. (2019)	Drivers and barriers to circular economy implementation: An explorative study in Pakistan's automobile industry.
Bag et al. (2019)	Examining the role of dynamic remanufacturing capability on supply chain resilience in circular economy.
Zhu, Geng, Sarkis, et al. (2011)	Evaluating green supply chain management among Chinese manufacturers from the ecological modernization perspective.
Caldera et al. (2019)	Evaluating the enablers and barriers for successful implementation of sustainable business practice in 'lean'' SMEs.
Cayzer et al. (2017)	Design of indicators for measuring product performance in the circular economy.
Long et al. (2016)	A sustainability assessment system for Chinese iron and steel firms.
Sihvonen & Partanen (2016)	Implementing environmental considerations within product development practices: A survey on employees' perspectives.

Authors	Article title
Y. Liu & Bai (2014)	An exploration of firms' awareness and behavior of developing circular economy: An empirical research in China.
Abreu & Ceglia (2018)	On the implementation of a circular economy: The role of institutional capacity-building through industrial symbiosis.
Xue et al. (2010)	Survey of officials' awareness on circular economy development in China: Based on municipal and county level.
Gaur et al. (2019)	Towards building circular economy: A cross-cultural study of consumers' purchase intentions for reconstructed products.
Lakatos et al. (2016)	How supportive are Romanian consumers of the circular economy concept: A survey.
Smol et al. (2018)	Public awareness of circular economy in southern Poland: Case of the Malopolska region.
Atlason et al. (2017)	Product design in the circular economy: Users' perception of end-of-life scenarios for electrical and electronic appliances.
Bovea et al. (2018)	Incorporation of circular aspects into product design and labelling: Consumer preferences.
Borrello et al. (2017)	Consumers' perspective on circular economy strategy for reducing food waste.
Q. Liu et al. (2009)	A survey and analysis on public awareness and performance for promoting circular economy in China: A case study from Tianjin.
Wang & Kuah (2018)	Green marketing cradle-to-cradle: Remanufactured products in Asian markets.
Tam et al. (2019)	Managing complex products to support the circular economy.
Unal et al. (2019)	Managerial practices for designing circular economy business models: The case of an Italian SME in the office supply industry.
Sihvonen & Partanen (2018)	A survey of perceived prevalence of selected environmental topics in product development, and their relationships with employee's ecological concern.
Dalhammar (2016)	Industry attitudes towards ecodesign standards for improved resource efficiency.
Bovea & Pérez-Belis (2018)	Identifying design guidelines to meet the circular economy principles: A case study on electric and electronic equipment.
Tura et al. (2019)	Unlocking circular business: A framework of barriers and drivers.
Dubey et al. (2019)	Supplier relationship management for circular economy: Influence of external pressures and top management commitment.
de Jesus & Mendonça (2018)	Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy.
Merli & Preziosi (2018)	The EMAS impasse: Factors influencing Italian organizations to withdraw or renew the registration.

None of the 43 articles analyzed considers all the items listed in the harmonized standards. These are the conclusions drawn from the table developed and shown in the supporting information document:

- Most of the questionnaires collected in the literature, do not give importance to the internal contexts of the company, they focus on aspects such as the market, customers, suppliers, etc. which though acceptable, do not consider the processes that are followed, the provision of products/services, and the non-conformities that the customer may have with the product/service among others.
- Regarding leadership, there are missing questions related to commitment and responsibilities, which are important for the correct management of the company.
- Regarding support processes, there is a lack of resources.
- Regarding operational processes, the questionnaires barely refer to the operational aspects of the companies. The items of materials and product/service design and development are the most mentioned in the majority of the questionnaires.
- As for stakeholders, there is no mention of environmental aspects, nor of management, partners, and internal staff. These points are important for the decision making that companies might need to engage in when defining changes.
- The developed questions do not have a direct relation to the CE solutions mentioned by Potting et al. (2017).
- The result of the questionnaires does not visualize an overall value of the diagnosis performed nor does it relate them to CE strategies.
- The information provided by the questionnaires of the articles identified in the literature review, shows the variety of question types: i) value scale, ii) open questions and iii) yes/no answer.

3.3 CE diagnostic tools

Based on the previous bibliographic review and the knowledge of the research team, main existing diagnostic tools were identified as of September 2021:

- CIRCelligence by Boston Consulting Group (BCG) (Rubel et al. 2020).
- Circularity Gap Metric by Haigh et al. (2019).
- Circulytics by Ellen MacArthur Foundation (2019).
- Circular Transition Indicator (CTI) by World Business Council for Sustainable Development (WBCSD, 2020).
- Circularity Check by Ecopreneur (2019).
- Circular Economy Indicator Prototype (CEIP) develop by Cayzer et al. (2017).
- CIRCit by Kravchenko et al. (2010).
- Making the Transition to Circular Economy (MAТChE) by Technical University of Denmark (2019).
- Circular Economy Toolkit (CET) by Evans et al. (2019).

Table 4 was created where the questions identified in the tools are related to the items of the harmonized standards, following the structure shown in the Table 2.

Table 4: Harmonized standards items Vs. Review of tool questions

			Diagnosis Tools								
			CIRCelligence	Circularity Gap Metric	Circulytics	CTI	Circularity Check	CEIP	CIRCit	MATChE	CET
	Harmonized standards items										
External context	Legislative									X	
Internal context	Leadership	Politics			X						
		Compromise							X		
		Responsibilities									
	Support	Resources								X	
		Awareness			X					X	
		Communication			X						
		Marketing									
		Documented information			X				X		
	Operations	Product/Service Requirements			X						X
		Materials	X	X	X	X			X		
		Design and Development					X	X	X		X
		Processes, products, and services supplied externally									
		Production and service provision					X	X			X
		Product / Service release									
		Control of non-conforming outputs									X
		Emergency response									
		Logistics/Reverse logistics					X		X		X
Stakeholders	Technological									X	
	Market								X	X	
	Sociocultural										
	Economical										
	Environmental				X		X				
	Clients				X		X		X		
	Consumers						X				
	Supplier				X						
	Partners				X				X		
	Internal staff										
	Competitors										
	Administration										

It is striking that there is little relationship between questions in the tools and items. This may indicate that the groups developing these tools have not taken into consideration the harmonized standards when designing the questionnaires but have only focused on providing a CE approach. The results of the questionnaires do not visualize an overall value, nor do they relate them to CE strategies and solutions (Potting et al., 2017).

4. Development, application, validation and results

4.1 Questionnaire design and development

ICEQ, as mentioned above, is a self-diagnostic questionnaire composed of 165 questions (available in the supporting information file; *SP2. ICEQ questionnaire*). For the creation of *ICEQ*, the methodology was as follows: i) read 750 questions identified in the literature review, ii) read questions of the diagnostic tools, iii) analyze wording, iv) create a relationship between questions and items of harmonized standards (ISO 9001:2015 and ISO 14001:2015), v) ensure questions are related to CE strategies and solutions, and v) draft questions for the final questionnaire.

ICEQ's objective is to help BAC industrial companies to integrate both CE strategies and solutions into their operational process without the need to obtain a new certification. With the newly questionnaire, companies are offered more complete analysis by relating questions to ISO 9001:2015, ISO 14001:2015, and CE solutions and strategies. The results obtained are qualitative.

Figure 2 shows the number of questions related to each of the different groups of the questionnaire. This provides a complete analysis of company's internal and external contexts. Not only the company's operational processes are considered, but also questions are asked about both strategy and support processes. In addition, external aspects are also asked to contextualize changes that may be needed. The questionnaire as mentioned above is available as *SP2. ICEQ questionnaire*. There you will find all the questions of the questionnaire grouped according to internal and external context.

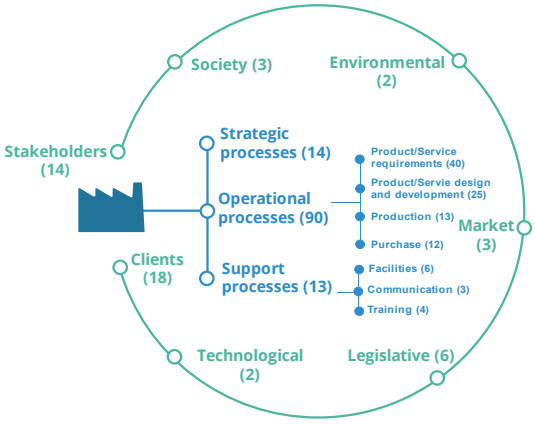

Figure 2: Number of questions associated with each group

ICEQ uses different response options: i) multiple choice, ii) open-ended, iii) answers to develop, and iv) Likert scale depending on the level of implementation (Hill et al., 2006). Likert scale was defined in 5 points, *1=Totally disagree* and *5= Totally agree*, and with the additional option, *Not applicable* (which is considered as a blank answer). This measurement system enables descriptive analysis and highlights correlations between different fields and subjects. The various options for answers make it possible to differentiate, i) answers to considered obtaining the results (Likert scale) and ii) answers where companies can write down their ideas, which are not used to obtain the final results, but they help the companies to specify aspects of what they are analyzing with the questionnaire and ensure that the answers they are giving are in accordance with the analysis. Figure 3 shows improvements opportunities obtained after answering the questionnaire.

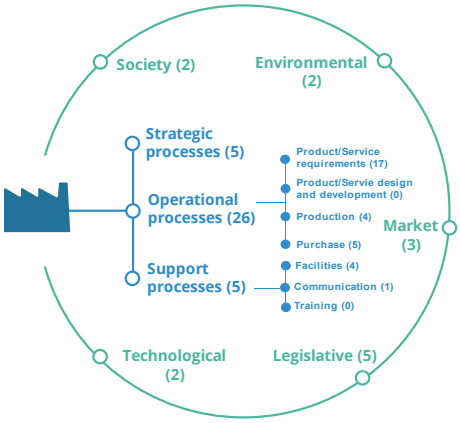

Figure 3: Improvements opportunities

The number of opportunities is obtained when the answers to each questions have a value <3. Finally, mention that *ICEQ* is an online questionnaire, which makes it easy for participants to i) fill it out anywhere, provided they have a technological device, and ii) obtain the results instantly. It is important to know that: i) companies have the option of completing the questionnaire at different times, but ii) once they have submitted the questionnaire, they are unable to alter the answers.

4.2 Application and validation

The method of attracting companies to test *ICEQ* consisted of holding open days that any company could participate in. Of all calls made, 30 companies from 17 different sectors in the BAC decided to participate (Table 5). These first cases were all carried out in face-to-face meetings, before the health crisis caused by Covid-19.

To conduct *ICEQ* the team formed by 2-3 people, visited each company. Before starting with the questionnaire, we explained the basic concepts of CE to participants, usually one or two people from different departments such as general managers, product managers, or quality and environment managers among others. After, a hardcopy of *ICEQ* was provided to participants. Sessions, which lasted two hours, were recorded with the permission of those present, so as not to lose information about what was being discussed. While participants were filling out *ICEQ*, we noted changes they proposed regarding the questions, and then we acted on their feedback.

Table 5: Summary of participating companies

Company	European Activity Name	Nº of employees	Contact
A	Manufacture of other machine tools	11-49 employees (small company)	Manager and Commercial
B	Manufacture of other machine tools	50-249 employees (medium company)	Product Manager
C	Manufacture of other machine tools	11-49 employees (small company)	Manager
D	Manufacture of other machine tools	50-249 employees (medium company)	Quality and Design
E	Manufacture of other machine tools	50-249 employees (medium company)	I+D Director
F	Repair of other equipment	11-49 employees (small company)	Manager
G	Repair of other equipment	50-249 employees (medium company)	Quality, I+D
H	Repair of other equipment	11-49 employees (small company)	I+D Manager
I	Repair of other equipment	>250 employees (big company)	Manager
J	Machining and metalworking transformation	11-49 employees (small company)	Manager
K	Machining and metalworking transformation	11-49 employees (small company)	General Manager

Company	European Activity Name	Nº of employees	Contact
L	Machining and metalworking transformation	11-49 employees (small company)	Manager
M	Health	11-49 employees (small company)	Manager
N	Health- Biotechnology	1-10 employees (micro company)	I+D Manager, Marketing Manager and Production Manager
O	Remediation activities and other waste management services	1-10 employees (micro company)	Manager
P	Remediation activities and other waste management services	>250 employees (big company)	I+D Manager
Q	Packaging	11-49 employees (small company)	Manager
R	Packaging	50-249 employees (medium company)	I+D Director
S	Automotive	>250 employees (big company)	Environmental officer
T	Automotive	>250 employees (big company)	Environmental officer
U	Repair of other personal and household goods	>250 employees (big company)	Business unit manager
V	Manufacture of other textiles	50-249 employees (medium company)	Manager
W	Agrifood	50-249 employees (medium company)	Quality I+D
X	Manufacture of office and shop furniture	50-249 employees (medium company)	Manager
Y	Manufacture of other food products	>250 employees (big company)	Director of operations
Z	Logistics mobility- Construction	>250 employees (big company)	Head of Innovation and Strategy
AA	Steelwork	50-249 employees (medium company)	Product Manager
AB	Chemical industry	11-49 employees (small company)	Quality
AC	Construction	>250 employees (big company)	Environmental and Quality Manager
AD	Manufacture of railway locomotives and rolling stock	>250 employees (big company)	Environmental officer

The target of the meetings referenced above was the following: i) get results of the survey, and ii) collect the impressions. There were clear objectives to be achieved through the meetings: i) be able to provide the necessary explanations in case of doubts, and ii) involve them to find solutions to their uncertainties while filling in the questionnaire.

In addition, at the end of the meeting and once *ICEQ* been completed, the companies were given a short evaluation questionnaire to assess the usefulness, ease of use, and validity of *ICEQ*, among other things, of which the results obtained were very positive. Proof of this, of the 30 participating companies, 93.3% of them mentioned that *ICEQ* has helped them to start working on CE. Furthermore, 56.7% say that the questionnaire is complete and easy to fill in. This data was analyzed and evaluated by the team members in order to make changes, such as rewriting the questions, and improve the results. Finally, to the question "would you recommend ICEQ to other companies" 100% of the answers were affirmative. The questionnaire and results can be seen in *SP3. Questionnaire to evaluate ICEQ*.

4.3 Results

Once *ICEQ* has been completed, participants receive quantitative results on the spot, which are divided as follows: i) overall assessment, ii) internal context assessments, related with the harmonized standards and CE solutions, and iii) CE strategies assessments, related to the solutions. The levels defined in Table 6 were adapted to the needs of the questionnaire having as main basis the maturity levels defined in BSI 8001:2017 (The British Standards Institutions, 2017).

Table 6: Levels of overall assessment adapted from BSI 8001:2017

Level	Scores	Definition
Incipient	1-1.8	The organizations perform limited actions in relations to the CE, limiting itself to compliance with the legal requirements. The organization can begin to take the first steps to base its business model on CE.
Basic	1.8-2.6	The organization shows signs of interest in basing its business model on CE. The organization can begin to take the first steps towards the transition to CE.
Operational	2.6-3.4	There are ways of knowledge that fit with principles of CE but is not systematized. The organization has the potential to base its business model on CE. There is a lack of awareness in the organization's strategy.
Commitment	3.4-4.2	The organization's offer is aligned with CE. The organization focuses efforts on product/service innovation. This innovation should be taken to a business model level.
Strategic	4.2-5	The organizational forms, business model and value proposition are aligned with CE.

Before delving into the analysis of results, it should be mentioned that scores obtained by each of the companies may vary depending on the person who completed the self-diagnosis, since his or her perspective may differ from that of a colleague. For this reason, although an analysis of the results has been made, it is not possible to speak specifically about the reasons for these scores.

4.3.1 Companies overall assessment

According to Topaloğlu & Er (2017) the literature highlights the design in leading and shaping companies strategies, conceiving new business models, and driving organizational changes and renewals. Research reveals that design can also be a valuable resource in the formation of strategy by helping to define corporate objectives and by providing ideas about business possibilities, new directions and opportunities that can inspire and shape strategy (Bruce & Bessant, 2002; Sanchez, 2006; Weiss, 2002). Therefore, when defining the percentages of both the main groups, to obtain the overall assessment, and the internal contexts, the score for design-related aspects has been emphasized, giving greater importance to the company's operating processes.

Figure 4 shows the overall results obtained by the industrial companies, divided into corresponding sectors.

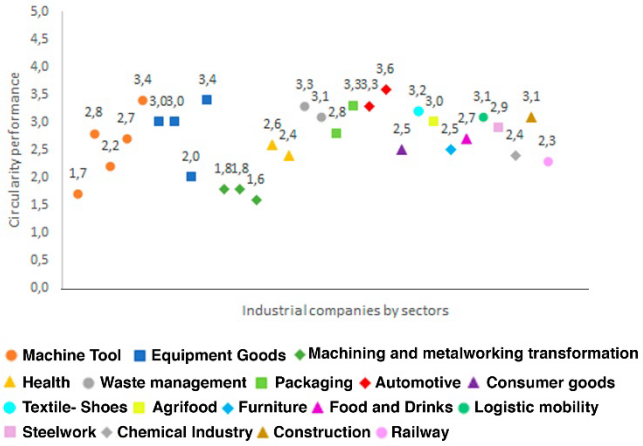

Figure 4: Companies overall assessment

The overall results of the companies completing the questionnaire are obtained by considering the following percentages: i) 30% of the result obtained with the strategic process questions, ii) 50% of the result obtained with the operational process questions, and iii) 20% of the result of the support process questions.

Out of 30 companies, 63% of them exceed the result of 50% and are positioned at the operational level. Of these sectors, Automotive is the most outstanding. Conversely, 37%

of the companies do not reach the operational level, Machining and Metalworking Transformation sector being the worst.

4.3.2 Internal context assessment

Granted that 80% of the total impact of the product is determined in the design phase (Charter & Tischner, 2017; European Commision et al., 2014) and defining the specification from the beginning of the design allows to optimize the design under that feature (Chakrabarti et al., 2004) it is important to consider the requirements of the product/service offered to reduce its impact on the environment (Casamayor & Su, 2013). Therefore, the results of the internal contexts are obtained by considering the answers given by the companies in the questionnaire and applying the percentages specified below for each of them: i) strategic processes: average of the answers. ii) operational process: 50% of the average of answers obtained in the product/service requirements questions, 30% of the average of product/service development questions, 10% of the average production group answers and 10% of the average of purchase group answers, and iii) support process: average of the answers.

Figure 5 shows the results obtained by the companies in each of the internal contexts.

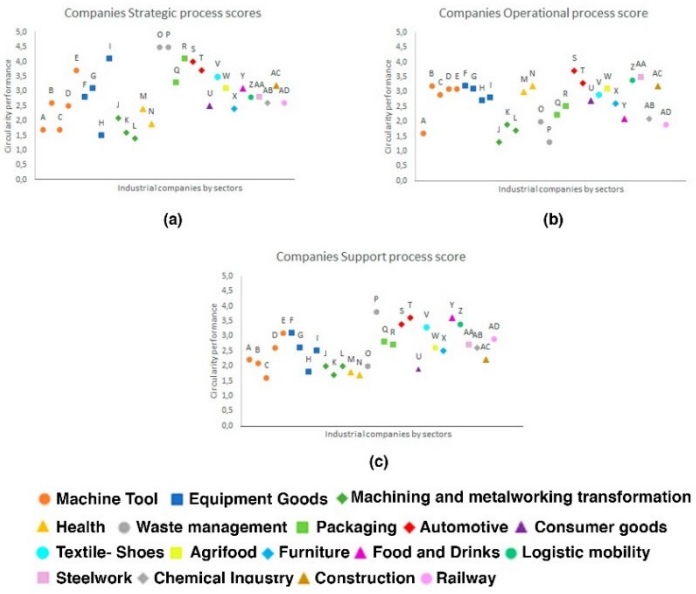

Figure 5: Company scores of internal contexts: (a) strategic process, (b) operational process and (c) support process

Looking at the results of the strategic process, Waste Management sector indisputably stands as it integrates the closing of cycles in the strategy. On the other hand, Machining and Metalworking Transformation sector scored the lowest, 34%.

In terms of operational processes, the most outstanding sector is Automotive, with an average of 70%. This can be attributed to the fact that automotive companies must comply with End-of-Life Vehicles (EoLV) legislation. Contrastingly, once again Machining and Metalworking Transformation is the sector with the lowest result.

Finally, checking the support process results of the companies, the best positioned sector is Automotive, 70%. Conversely, Health is the sector with the lowest score, 36%.

4.3.3 Companies CE strategies assessment

Figure 6 shows all the scores obtained by the companies in relation to the CE strategies. Regarding the way to obtain the results of the CE strategies, an average is carried out in each of the strategies considering the questions that affect each of the 4 groups.

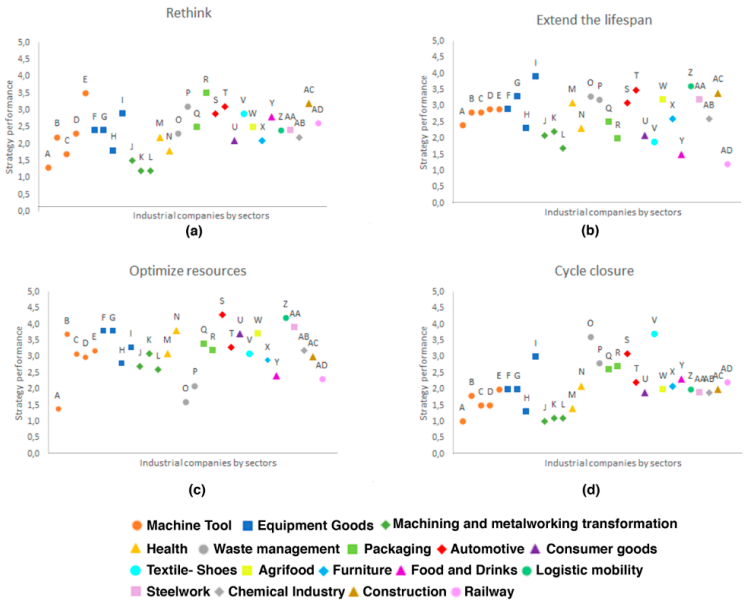

Figure 6: Company scores of CE strategies: (a) rethink, (b) extend the lifespan, (c) optimize resources and (d) cycle closure

Analyzing *rethink* solution, the sectors with the highest average are Packaging and Automotive, both scoring 60%. This is because these sectors have changes in legislation. However, Machining and Metalworking Transformation sector is the worst with a score of 26%.

The highest results for extending lifespan were in Logistic Mobility sector (72%). In contrast, Railway sector is the worst ranked with a score of 24%. In terms of optimizing resources, the sector with the highest score is Logistic Mobility, 84%. On the other hand, with a score of 38% Waste Management is the worst positioned. Finally, closing of cycles is led by the Textile-Shoes sector 74%, in comparison, Machining and Metalworking Transformation sector is the worst positioned (22%).

5. Discussion

5.1 Insights and lessons learned

First and arguably most importantly, *ICEQ* was developed within the project CircularTRANS financed by the Gipuzkoa Provincial Council of BAC in Spain. The objective was to get industrial companies to move towards CE by improving their competitiveness with the results of the self-diagnosis as the main basis. The proposed process of holding meetings with disciplinary teams can be considered the most concrete way of using *ICEQ*. In a generic approach, meetings and teamwork can be combined not only for *ICEQ* implementation, but also for opportunity assessment and decision making. The process aided the commitment of the participants, the effort, speed, and simplicity of its use, which is adequate to conceptualize the opportunities and options for achieving objectives. All of this was supplemented by best practice examples from both national or international industrial companies and with the option of using tools as an aid.

It is worth mentioning that during the entire process of designing, developing, and implementing *ICEQ*, it has been found that companies lack knowledge about what CE is. Therefore, all the companies participating in the case studies benefited from the first meeting to clarify concepts and to be able to address the internal processes in which they will have to work. This helped them to be aware of the changes they should make after completing the questionnaire and obtaining the results.

Thanks to meetings we were also able to obtain feedback from the participants. From all feedback received, these were the conclusions we drew: i) some questions were not fully understood, ii) the need to create a multidisciplinary team, iii) time to carry out the questionnaire seriously to get reliable results, and iv) commitment on the part of the team.

In order to provide solutions to the comments and avoid making the same mistakes again, the following was done after obtaining feedback from the participating companies: i) all the questions were read and rewritten, ii) the questionnaire was improved, making the participants capable of completing it without specific help from the team experts, iii) the importance of creating a multidisciplinary team was emphasized, since in some cases the participants did not have a global vision of the company (although the final decision is made by the organizations), and iv) it was advised to take time to complete the *ICEQ* as there may be a diversity of opinions. Once the improvements had been made, some companies re-read the questionnaire and validated the changes made.

It should be noted that not all feedback received was negative. Participants emphasized that: i) it helped them to devise possible improvements, ii) introduce employees to CE by demonstrating its importance, and iii) have clear objectives going in the same directions and improving the business model, thus making them more competitive in the market.

It is difficult to track what changes will happen after the first meeting with the company. However, anecdotal evidence from meetings held a couple of months later indicated that the senior staff really engaged with the questionnaire and are now exploring new methods and paths to achieve their opportunities. The most important outcome, we were told, is top management buy-in. This was also confirmed by employees of other cases, whom *ICEQ* helped to catalyze new ideas, communicate to their superiors, and get the managers support to start with the changes. Last but not least, it should be noted that participants reported that the training process and support offered helped them to better understand CE and to clarify doubts on the subject. Furthermore, they came up with ideas to address the opportunities they must work on.

5.2 Contributions and implications

The present study was the first attempt to integrate elements of harmonized standards and CE strategies and solutions together into a questionnaire, allowing companies to carry out a self-diagnosis of their own situation with respect to circularity and to work out the opportunities for improvement that are offered to them. While there is a wide range of tools available, it was found that there was a lack of tools that integrate these considerations. Our research addresses this concern and adds to the tools that are currently available.

ICEQ, which is strictly a self-diagnostic questionnaire, helps to obtain the company's CE diagnosis from the results of the questionnaire, which can be seen as an opportunity to expand the company's competitiveness and embrace additional ways of working. Consequently, it can be a valuable step in both conventional and sustainable business processes. Finally, it can facilitate the creation of viable business models, even for small companies.

5.3 Strengths and limitations

Firstly, we would like to mention both positive aspects and limitations of the methodology designed. The speed with which the companies received the results once the diagnosis had been carried out and the ease of use of the questionnaire were remarkable. However, only with the questionnaire and improvement opportunities, it does not offer concrete solutions according to needs. Although it is true that companies have the resources to be able to start the change, they can only do so with expert help.

Regarding the number of participating companies per sector, in some cases there is only one company, so the representativeness of the industries can be considered very low. However, this does not mean that the results obtained have not been considered, but on the contrary, it has helped us to have an idea of the needs that companies in these sectors may have, without generalizing since each company in the same sector may work with CE in a different way. Even so, we will continue to look for companies in the less representative sectors, without forgetting the rest, in order to achieve greater representation and thus obtain more accurate conclusions for each sector.

Finally, although it is not directly related to *ICEQ*, it is true that many companies are still reluctant to start working with CE. This means that, although companies are offered the opportunity to use the questionnaire, they do not take it into consideration.

5.4 Future improvements

One of the improvements to be made is the integration of the rest of the harmonized standards analyzed, such as ISO 56002:2019, ISO 14006:2020, BSI 8001:2017, to obtain a much more complete questionnaire and ensure that all types of aspects in which the company will obtain greater benefit are worked on.

ICEQ intended to be independent of industry, size, or maturity of company. Future research will involve adapting and testing *ICEQ* for other markets/sectors, such as tourism, education, consulting, etc. so that they can also improve their businesses. Furthermore, a complete 5-step process will be created where *ICEQ* will be the first. With the diagnosis, results, and opportunity selection a roadmap and action plan will be created to give the company the option of carrying out the process in its entirety. The complete process is called CircularTRANS.

This process is shown in Figure 7 which starts with a diagnostic part where companies complete *ICEQ* self-diagnostic questionnaire, obtain the results and select opportunities to work on the basis of these results. The fourth step consists of defining a roadmap and finally an action plan to address CE opportunities. More information about the platform can be found at https://circulartrans.mondragon.edu/en/home.

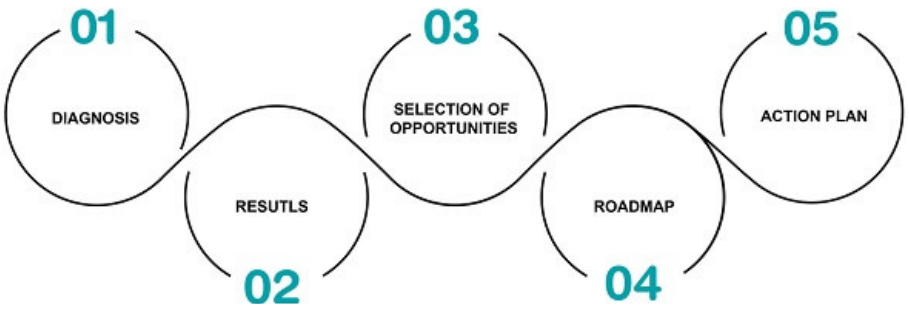

Figure 7: CircularTRANS complete process

In addition, we want to add CE indicators and be able to quantify the improvements. This will allow managers to ensure that the entire process is helping them to improve their competitiveness. Moreover, we want to work on Life Cycle Assessment (LCA) so that companies have more options when carrying out the identified changes. The field work must be very strict and rigorous. The first thing is to define good indicators where it can measure the progress or setbacks that the participating industrial company is making. This must be put into practice in more than one company, in order to improve three aspects: i) be aware that the tool continues to work and offer the pre-established conditions, ii) companies are able to see improvements, and iii) continue to receive feedback to improve the tool and adapt it to possible new needs that arise from its use. Lastly, the possibility of integrating the CE management systems in organizations with the help of the group's experts is being considered.

6. Conclusions

This study proposes *ICEQ*: as a continuous improvement questionnaire to start the circularity process, aimed at industrial companies in BAC which allows companies with an insight into internal and external contexts in order to integrate them into their business model. A 165-question questionnaire has been developed taking as a reference, questionnaires identified in the literature review together with questions identified in the different CE tools available. Additionally, the creation of this questionnaire has considered both the strategies and solutions of CE, as well as aspects analyzed in the harmonized standards that industrial companies must comply with to guarantee the quality of their products/services.

The review conclusion is that all companies considered this questionnaire as a viable starting point to change and achieve a more circular business model working different aspects and being a beginning of continuous improvement. *ICEQ*, a questionnaire aimed at industrial companies, helps to make the results of the review useful internally for companies. The questionnaire has been tested for "usability", “self-improvement” and "ease of use" in 30 industrial companies of different sizes and sectors to ensure that *ICEQ* has practical value.

Still based on these iterations, and the feedback received from companies, and concluding that the questionnaire is suitable to begin the transition to CE, we realize that: companies need specific tools to quantitatively assess the contribution of CE, therefore, it is necessary to work on CE indicators, LCA, etc. With these needs in mind, the team will continue to work in these areas to meet the needs of industrial companies.

Acknowledgements

The authors would like to thank Joan Manuel F. Mendoza for the comments and suggestions provided in earlier versions of the paper, to Ander Elizburu for his support and the Economic Promotion, Tourism and Rural Environment Department of Gipuzkoa region council (Spain’s Basque region) for providing us with company contacts and companies that participated in the project and also for the funding of CircularTRANS project.

References

Abreu, M. C. S. de, & Ceglia, D. (2018). On the implementation of a circular economy: The role of institutional capacity-building through industrial symbiosis. *Resources, Conservation and Recycling*, *138*, 99–109. https://doi.org/10.1016/j.resconrec.2018.07.001

AENOR. (2015). *Certificación ISO 9001- AENOR*. https://www.aenor.com/certificacion/calidad/iso-9001

AENOR. (2020). *UNE-ISO 56002:2020 Gestión de la innovación. Sistema de gestió...* https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma/?c=N0063286

AFNOR. (2020). *A practical guide to getting into circular economy - AFNOR Group*. https://www.afnor.org/en/news/practical-guide-circular-economy/

Aghaei Chadegani, A., Salehi, H., Yunus, M., Farhadi, H., Fooladi, M., Farhadi, M., & Ale Ebrahim, N. (2013). A comparison between two main academic literature collections: Web of Science and Scopus databases. *Asian Social Science*, *9*(5), 18–26.

Agyemang, M., Kusi-Sarpong, S., Khan, S. A., Mani, V., Rehman, S. T., & Kusi-Sarpong, H. (2019). Drivers and barriers to circular economy implementation: An explorative study in Pakistan's automobile industry. *Management Decision*, *57*(4), 971–994. https://doi.org/10.1108/MD-11-2018-1178

Atlason, R. S., Giacalone, D., & Parajuly, K. (2017). Product design in the circular economy: Users' perception of end-of-life scenarios for electrical and electronic appliances. *Journal of Cleaner Production*, *168*, 1059–1069. https://doi.org/10.1016/j.jclepro.2017.09.082

Bag, S., Gupta, S., & Foropon, C. (2019). Examining the role of dynamic remanufacturing capability on supply chain resilience in circular economy. *Management Decision*, *57*(4), 863–885. https://doi.org/10.1108/MD-07-2018-0724

Bassi, F., & Dias, J. G. (2019). The use of circular economy practices in SMEs across the EU. *Resources, Conservation and Recycling*, *146*, 523–533. https://doi.org/10.1016/j.resconrec.2019.03.019

Blomsma, F., Pieroni, M., Kravchenko, M., Pigosso, D. C. A., Hildenbrand, J., Kristinsdottir, A. R., Kristoffersen, E., Shahbazi, S., Nielsen, K. D., Jönbrink, A.-K., Li, J., Wiik, C., & McAloone, T. C. (2019). Developing a circular strategies framework for manufacturing companies to support circular economy-oriented innovation. *Journal of Cleaner Production*, *241*, 118271. https://doi.org/10.1016/J.JCLEPRO.2019.118271

Bluhm, D. J., Harman, W., Lee, T. W., & Mitchell, T. R. (2011). Qualitative research in management: A decade of progress. *Journal of Management Studies*, *48*(8), 1866–1891. https://doi.org/10.1111/J.1467-6486.2010.00972.X

Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

Bocken, N. M. P., Olivetti, E. A., Cullen, J. M., Potting, J., & Lifset, R. (2017). Taking the Circularity to the Next Level: A Special Issue on the Circular Economy. *Journal of Industrial Ecology*, *21*(3), 476–482. https://doi.org/10.1111/jiec.12606

Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S., & Cembalo, L. (2017). Consumers' perspective on circular economy strategy for reducing food waste. *Sustainability (Switzerland)*, *9*(1). https://doi.org/10.3390/su9010141

Bovea, M. D., Ibáñez-Forés, V., Pérez-Belis, V., Juan, P., Braulio-Gonzalo, M., & Díaz-ávalos, C. (2018). Incorporation of circular aspects into product design and labelling: Consumer preferences. *Sustainability (Switzerland)*, *10*(7). https://doi.org/10.3390/su10072311

Bovea, M. D., & Pérez-Belis, V. (2018). Identifying design guidelines to meet the circular economy principles: A case study on electric and electronic equipment. *Journal of Environmental Management*, *228*, 483–494. https://doi.org/10.1016/j.jenvman.2018.08.014

Bruce, Margaret., & Bessant, J. R. (2002). *Design in business : strategic innovation through design*. 287. https://www.researchgate.net/publication/235700981_Design_in_Business_Strategic_Innovation_Through_Design

BS 8001. (2017). *BS 8001 - La primera norma de Economía Circular | BSI*. https://www.bsigroup.com/es-ES/Normas/Las-ventajas-del-uso-de-las-normas/Como-hacerse-mas-sostenible-con-las-normas/bs-8001-economia-circular/

Caldera, H. T. S., Desha, C., & Dawes, L. (2019). Evaluating the enablers and barriers for successful implementation of sustainable business practice in 'lean'' SMEs.' *Journal of Cleaner Production*, *218*, 575–590. https://doi.org/10.1016/J.JCLEPRO.2019.01.239

Casamayor, J. L., & Su, D. (2013). Integration of eco-design tools into the development of eco-lighting products. *Journal of Cleaner Production*, *47*, 32–42. https://doi.org/10.1016/J.JCLEPRO.2013.02.011

Casas Anguita, J., Repullo Labrador, J. R., & Donado Campos, J. de M. (2002, April 24). *La encuesta como técnica de investigación. Elaboración de cuestionarios y tratamiento estadístico de los datos* . http://www.unidaddocentemfyclaspalmas.org.es/resources/9+Aten+Primaria+2003.+La+Encuesta+I.+Custionario+y+Estadistica.pdf

Cayzer, S., Griffiths, P., & Beghetto, V. (2017). Design of indicators for measuring product performance in the circular economy. *International Journal of Sustainable Engineering*, *10*(4–5), 289–298. https://doi.org/10.1080/19397038.2017.1333543

Ceptureanu, S.-I., Ceptureanu, E.-G., & Murswieck, R. G. D. (2018). Perceptions of circular business models in SMEs. *Amfiteatru Economic*, *20*(48), 310–324. https://doi.org/10.24818/EA/2018/48/310

Chakrabarti, A., Morgenstern, S., & Knaab, H. (2004). Identification and application of requirements and their impact on the design process: A protocol study. *Research in Engineering Design*, *15*(1), 22–39. https://doi.org/10.1007/S00163-003-0033-5

Charter, M., & Tischner, U. (2017). Sustainable solutions: Developing products and services for the future. *Sustainable Solutions: Developing Products and Services for the Future*, 1–469. https://doi.org/10.4324/9781351282482

Circle Economy. (2021). *Circularity GAP Report 2021*. https://www.circularity-gap.world/2021

Cristoni, N., & Tonelli, M. (2018). Perceptions of Firms Participating in a Circular Economy. *EUROPEAN JOURNAL OF SUSTAINABLE DEVELOPMENT*, *7*(4), 105–118. https://doi.org/10.14207/ejsd.2018.v7n4p105

Dalhammar, C. (2016). Industry attitudes towards ecodesign standards for improved resource efficiency. *Journal of Cleaner Production*, *123*, 155–166. https://doi.org/10.1016/j.jclepro.2015.12.035

de Jesus, A., & Mendonça, S. (2018). Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecological Economics*, *145*, 75–89. https://doi.org/10.1016/j.ecolecon.2017.08.001

643 Dubey, R., Gunasekaran, A., Childe, S. J., Papadopoulos, T., & Helo, P. (2019). Supplier
644 relationship management for circular economy: Influence of external pressures and
645 top management commitment. *Management Decision*, *57*(4), 767–790.
646 https://doi.org/10.1108/MD-04-2018-0396

647 Ecopreneur. (2019). *Circularity Check*. https://ecopreneur.eu/circularity-check-landing-
648 page/

649 Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Source: The*
650 *Academy of Management Review*, *14*(4), 532–550.

651 Ellen MacArthur Foundation. (2017). The Circular Economy in Detail. In *Learning Hub*.
652 https://www.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail

653 Ellen MacArthur Foundation. (2019). *"Circulytics: measuing circularity."*
654 https://www.ellenmacarthurfoundation.org/ resources/apply/circulytics -measuring-
655 circularity

656 Ellen Macathur Foundation. (2015, November). *Towards a Circular Economy: Business*
657 *rationale for an accelerated transition*.
658 https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Ell
659 en-MacArthur-Foundation_26-Nov-2015.pdf

660 EMAS. (2014). *El Reglamento EMAS Guía práctica*.

661 European Commision, D., General for Energy, D., & General for Enterprise and Industry.
662 (2014). *Ecodesign your future: how ecodesing can help the environment by making*
663 *products smarter*. https://data.europa.eu/doi/10.2769/38512

664 European Commission. (2015). *Closing the loop An EU action plan for the Circular*
665 *Economy* (Vol. 7, Issue 5).

666 European Commission. (2019). *Communication from the commission to the European*
667 *Parlament, the European Council, the European Economic and Social Committee*
668 *and the Committee of the Regions- The European Green Deal*.
669 https://ec.europa.eu/info/sites/info/files/european-green-deal-
670 communication_en.pdf

671 European Union. (2021, May 10). *Standardisation in Europe – technical requirements -*
672 *harmonized standards - ce marking - Your Europe*.
673 https://europa.eu/youreurope/business/product-
674 requirements/standards/standards-in-europe/index_en.htm

675 Evans, J., Bocken, N., & University of Cambridge. (2019). *Circular Economy Toolkit*.
676 http://circulareconomytoolkit.org/Toolkit.html

677 Fonseca, L. M., Domingues, J. P., Pereira, M. T., Martins, F. F., & Zimon, D. (2018).
678 Assessment of circular economy within Portuguese organizations. *Sustainability*
679 *(Switzerland)*, *10*(7). https://doi.org/10.3390/su10072521

680 Gabarró Sust, J. (2021). *Certificados ISO y economía circular - Normes ISO*.
681 https://iso.cat/es/certificados-iso-y-economia-circular/

682 Gaur, J., Mani, V., Banerjee, P., Amini, M., & Gupta, R. (2019). Towards building circular
683 economy: A cross-cultural study of consumers' purchase intentions for
684 reconstructed products. *Management Decision*, *57*(4), 886–903.
685 https://doi.org/10.1108/MD-07-2018-0728

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? In *Journal of Cleaner Production* (Vol. 143, pp. 757–768). https://doi.org/10.1016/j.jclepro.2016.12.048

Haigh, L. A., von Daniels, C., de Wit, M., & Hoogzaad, J. (2019). *CGR 2021*. https://www.circularity-gap.world/2021

Hill, T., Lewicki, P., & Lewicki, P. (2006). *Statistics: methods and applications: a comprehensive reference for science, industry, and data mining*. StatSoft, Inc.

Hojnik, J., Ruzzier, M., & Manolova, T. (2017). Eco-innovation and firm efficiency: Empirical evidence from Slovenia. *Foresight and STI Governance*, *11*(3), 103–111. https://doi.org/10.17323/2500-2597.2017.3.103.111

Hopff, B., Nijhuis, S., & Verhoef, L. A. (2019). New dimensions for circularity on campus-framework for the application of circular principles in campus development. *Sustainability (Switzerland)*, *11*(3). https://doi.org/10.3390/su11030627

Horielikova, L. (2020, November 3). *ISO certification: Which standards are the most popular?* https://advisera.com/blog/2020/11/03/which-iso-standards-are-the-most-popular-analysis-of-iso-2019-survey/

ISO 14001:2015. (2016). *Los factores de éxito y los objetivos de la norma ISO 14001 2015*. https://www.nueva-iso-14001.com/2016/06/los-factores-exito-los-objetivos-la-norma-iso-14001-2015/

Jakhar, S. K., Mangla, S. K., Luthra, S., & Kusi-Sarpong, S. (2019). When stakeholder pressure drives the circular economy: Measuring the mediating role of innovation capabilities. *Management Decision*, *57*(4), 904–920. https://doi.org/10.1108/MD-09-2018-0990

Jesson, J., Matheson, L., & Lacey, F. M. (2011). *Doing your literature review: Traditional and systematic techniques*. Sage.

Katz-Gerro, T., & López Sintas, J. (2019). Mapping circular economy activities in the European Union: Patterns of implementation and their correlates in small and medium-sized enterprises. *Business Strategy and the Environment*, *28*(4), 485–496. https://doi.org/10.1002/bse.2259

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence From the European Union (EU). *Ecological Economics*, *150*, 264–272. https://doi.org/10.1016/j.ecolecon.2018.04.028

Konietzko, J., Bocken, N., & Hultink, E. J. (2020). A tool to analyze, ideate and develop circular innovation ecosystems. *Sustainability (Switzerland)*, *12*(1), 417. https://doi.org/10.3390/SU12010417

Kravchenko, M., Pigosso, D. C. A., & McAloone, T. C. (2010). *A guidance for navigating trade-offs to support sustainability-related decision-making*. https://doi.org/https://doi.org/10.11583/DTU.12933431

Kumar, V., Sezersan, I., Garza-Reyes, J. A., Gonzalez, E. D. R. S., & AL-Shboul, M. A. (2019). Circular economy in the manufacturing sector: benefits, opportunities and barriers. *Management Decision*, *57*(4), 1067–1086. https://doi.org/10.1108/MD-09-2018-1070

Lakatos, E. S., Dan, V., Cioca, L. I., Bacali, L., & Ciobanu, A. M. (2016). How supportive are Romanian consumers of the circular economy concept: A survey. *Sustainability (Switzerland)*, *8*(8). https://doi.org/10.3390/su8080789

Legegunea. (2019). *LEY 4/2019, de 21 de febrero, de Sostenibilidad Energética de la Comunidad Autónoma Vasca. - Legegunea: Normativa del Pais Vasco - Gobierno Vasco - Euskadi.eus*. https://www.legegunea.euskadi.eus/eli/es-pv/l/2019/02/21/4/dof/spa/html/webleg00-contfich/es/

Liu, Q., Li, H. -m., Zuo, X. -l., Zhang, F. -f., & Wang, L. (2009). A survey and analysis on public awareness and performance for promoting circular economy in China: A case study from Tianjin. *Journal of Cleaner Production*, *17*(2), 265–270. https://doi.org/10.1016/j.jclepro.2008.06.003

Liu, Y., & Bai, Y. (2014). An exploration of firms' awareness and behavior of developing circular economy: An empirical research in China. *Resources, Conservation and Recycling*, *87*, 145–152. https://doi.org/10.1016/j.resconrec.2014.04.002

Long, Y., Pan, J., Farooq, S., & Boer, H. (2016). A sustainability assessment system for Chinese iron and steel firms. *Journal of Cleaner Production*, *125*, 133–144. https://doi.org/10.1016/j.jclepro.2016.03.030

Masi, D., Kumar, V., Garza-Reyes, J. A., & Godsell, J. (2018). Towards a more circular economy: exploring the awareness, practices, and barriers from a focal firm perspective. *Production Planning and Control*, *29*(6), 539–550. https://doi.org/10.1080/09537287.2018.1449246

Merli, R., & Preziosi, M. (2018a). The EMAS impasse: Factors influencing Italian organizations to withdraw or renew the registration. *Journal of Cleaner Production*, *172*, 4532–4543. https://doi.org/10.1016/j.jclepro.2017.11.031

Merli, R., & Preziosi, M. (2018b). The EMAS impasse: Factors influencing Italian organizations to withdraw or renew the registration. *Journal of Cleaner Production*, *172*, 4532–4543. https://doi.org/10.1016/j.jclepro.2017.11.031

Milios, L., Beqiri, B., Whalen, K. A., & Jelonek, S. H. (2019). Sailing towards a circular economy: Conditions for increased reuse and remanufacturing in the Scandinavian maritime sector. *Journal of Cleaner Production*, *225*, 227–235. https://doi.org/10.1016/j.jclepro.2019.03.330

Mintzberg, H. (1988). *La estructuración de las Organizaciones*.

Normas ISO. (2022). *Norma ISO 14006 de ecodiseño - Normes ISO*. https://iso.cat/es/norma-iso-14006-ecodiseno/

Ormazabal, M., Prieto-Sandoval, V., Puga-Leal, R., & Jaca, C. (2018). Circular Economy in Spanish SMEs: Challenges and opportunities. *Journal of Cleaner Production*, *185*, 157–167. https://doi.org/10.1016/j.jclepro.2018.03.031

Piyathanavong, V., Garza-Reyes, J. A., Kumar, V., Maldonado-Guzmán, G., & Mangla, S. K. (2019). The adoption of operational environmental sustainability approaches in the Thai manufacturing sector. *Journal of Cleaner Production*, *220*, 507–528. https://doi.org/10.1016/j.jclepro.2019.02.093

Potting, J., Hekkert, M. P., Worrell, E., & Hanemaaijer, A. (2017). Circular Economy: Measuring Innovation in the Product Chain. *Planbureau Voor de Leefomgeving*, *2544*. https://dspace.library.uu.nl/handle/1874/358310

Rocha, C. S., Antunes, P., & Partidário, P. (2019). Design for sustainability models: A multiperspective review. In *Journal of Cleaner Production* (Vol. 234, pp. 1428–1445). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2019.06.108

Rubel, H., Meyer zum Felde, A., Oltmanns, J., Lanfer, C., & Bayer, L. (2020). *CIRCelligence by BCG It's Time to Close Our Future Resource Loops*. https://web-

assets.bcg.com/72/a9/be8d79d94fa3ae10c84b446fd063/de-circelligence-by-bcg.pdf

Saidani, M., Yannou, B., Leroy, Y., & Cluzel, F. (2017). How to Assess Product Performance in the Circular Economy? Proposed Requirements for the Design of a Circularity Measurement Framework. *Recycling*, *2*(1), 6. https://doi.org/10.3390/recycling2010006

Sanchez, R. (2006). Integrating Design into Strategic Management Processes. *Design Management Review*, *17*(4), 10–17. https://doi.org/10.2/JQUERY.MIN.JS

Sariatli, F. (2017). Linear Economy Versus Circular Economy: A Comparative and Analyzer Study for Optimization of Economy for Sustainability. *Visegrad Journal on Bioeconomy and Sustainable Development*, *6*(1), 31–34. https://doi.org/10.1515/vjbsd-2017-0005

Siggelkow, N. (2007). Persuasion With Case Studies. *Https://Doi.Org/10.5465/Amj.2007.24160882*, *50*(1), 20–24. https://doi.org/10.5465/AMJ.2007.24160882

Sihvonen, S., & Partanen, J. (2016). Implementing environmental considerations within product development practices: A survey on employees' perspectives. *Journal of Cleaner Production*, *125*, 189–203. https://doi.org/10.1016/j.jclepro.2016.03.023

Sihvonen, S., & Partanen, J. (2018). A survey of perceived prevalence of selected environmental topics in product development, and their relationships with employee's ecological concern. *Journal of Cleaner Production*, *199*, 1116–1129. https://doi.org/10.1016/j.jclepro.2018.07.092

Smol, M., Avdiushchenko, A., Kulczycka, J., & Nowaczek, A. (2018). Public awareness of circular economy in southern Poland: Case of the Malopolska region. *Journal of Cleaner Production*, *197*, 1035–1045. https://doi.org/10.1016/j.jclepro.2018.06.100

Tam, E., Soulliere, K., & Sawyer-Beaulieu, S. (2019). Managing complex products to support the circular economy. *Resources, Conservation and Recycling*, 124–125. https://doi.org/10.1016/j.resconrec.2018.12.030

Technical University of Denmark. (2019). *MATChE - Making the Transition to Circular Economy*. https://www.matche.dk/

The British Standards Institutions. (2017). *Framework for implementing the principles of the circular economy in organizations – Guide* (p. 90).

Topaloğlu, F., & Er, Ö. (2017). Discussing a New Direction for Design Management through a New Design Management Audit Framework. *Design Journal*, *20*(sup1), S502–S521. https://doi.org/10.1080/14606925.2017.1353000

Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., & Valkokari, P. (2019). Unlocking circular business: A framework of barriers and drivers. *Journal of Cleaner Production*, *212*, 90–98. https://doi.org/10.1016/j.jclepro.2018.11.202

Unal, E., Urbinati, A., & Chiaroni, D. (2019). Managerial practices for designing circular economy business models The case of an Italian SME in the office supply industry. *JOURNAL OF MANUFACTURING TECHNOLOGY MANAGEMENT*, *30*(3, SI), 561–589. https://doi.org/10.1108/JMTM-02-2018-0061

Urbinati, A., Rosa, P., Sassanelli, C., Chiaroni, D., & Terzi, S. (2020). Circular business models in the European manufacturing industry: A multiple case study analysis. *Journal of Cleaner Production*, *274*. https://doi.org/10.1016/J.JCLEPRO.2020.122964

824 Wang, P., & Kuah, A. T. H. (2018). Green marketing cradle-to-cradle: Remanufactured
825 products in Asian markets. *Thunderbird International Business Review*, *60*(5), 783–
826 795. https://doi.org/10.1002/tie.21925

827 WBCSD. (2020). *CTI Tool*. https://ctitool.com/

828 Weiss, L. (2002). Developing tangible strategies. *Design Management Journal (Former*
829 *Series)*, *13*(1), 33–38. https://doi.org/10.1111/J.1948-7169.2002.TB00296.X

830 Xue, B., Chen, X.-P., Geng, Y., Guo, X.-J., Lu, C.-P., Zhang, Z.-L., & Lu, C.-Y. (2010).
831 Survey of officials' awareness on circular economy development in China: Based
832 on municipal and county level. *Resources, Conservation and Recycling*, *54*(12),
833 1296–1302. https://doi.org/10.1016/j.resconrec.2010.05.010

834 Yin, R. K. (2003). *Case Study Research Design and Methods* (Third, Vol. 5).

835 Zeng, H., Chen, X., Xiao, X., & Zhou, Z. (2017). Institutional pressures, sustainable
836 supply chain management, and circular economy capability: Empirical evidence
837 from Chinese eco-industrial park firms. *Journal of Cleaner Production*, *155*, 54–65.
838 https://doi.org/10.1016/j.jclepro.2016.10.093

839 Zhu, Q., Geng, Y., & Lai, K. (2010). Circular economy practices among Chinese
840 manufacturers varying in environmental-oriented supply chain cooperation and the
841 performance implications. *Journal of Environmental Management*, *91*(6), 1324–
842 1331. https://doi.org/10.1016/J.JENVMAN.2010.02.013

843 Zhu, Q., Geng, Y., & Lai, K.-H. (2011). Environmental supply chain cooperation and its
844 effect on the circular economy practice-performance relationship among Chinese
845 manufacturers. *Journal of Industrial Ecology*, *15*(3), 405–419.
846 https://doi.org/10.1111/j.1530-9290.2011.00329.x

847 Zhu, Q., Geng, Y., Sarkis, J., & Lai, K. (2011). Evaluating green supply chain
848 management among Chinese manufacturers from the ecological modernization
849 perspective. *TRANSPORTATION RESEARCH PART E-LOGISTICS AND*
850 *TRANSPORTATION REVIEW*, *47*(6), 808–821.
851 https://doi.org/10.1016/j.tre.2010.09.013

852