Circular Economy at the Firm Level: A New Tool for Assessing Maturity and Circularity

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Abstract: Although the circular economy (CE) concept is gaining traction and methods to assess companies’ CE-related aspects exist, there is no established CE assessment tool. In many cases, it is not clear how metrics or indicators included in extant CE assessment methods have been selected. To fill this gap, this paper presents a new instrument named Circularity and Maturity Firm-Level Assessment tool (CM-FLAT). The CM-FLAT has been developed starting from a transparent scientific basis, i.e., a recent systematic literature review and comprehensive collection of CE metrics. In addition, it targets the separate assessment of CE maturity, i.e., the presence of documented activities and practices laying the foundations for CE introduction, and circularity, i.e., attained CE-related performances. The development of the CM-FLAT has foreseen its formal evaluation by experts in the field of CE and sustainability, and its testing by a pilot group of companies from South Tyrol, Italy. The multiple verification activities have confirmed its usefulness and usability. Therefore, companies can now benefit from a tool capable of providing a comprehensive framework of factors and organizational areas affecting the introduction of the CE. This will be fostered by a computer-supported tool implementing the CM-FLAT, which represents the authors’ future work.

Keywords: CM-FLAT; circular economy assessment; micro-level assessment; circular economy metrics; maturity; circularity; circular value chain

1. Introduction

With the circular economy (CE) concept gaining traction over the last decade, companies and policymakers started to direct their attention to what is seemingly a promising tool to foster sustainable development [1–3]. As a result, an increasing number of scholars and practitioners have focused on the assessment of the progress of CE initiatives and, accordingly, on the development of performance measurement tools [4–8].

Despite the rising interest towards CE assessment methods, the lack of a sound, commonly agreed scientific basis and the low applicability of those methods in industrial realities are often cited as fundamental barriers to their uptake [9–12]. As a result, the industry is still characterized by a low CE performance and diffusion [13–15], and only a small fraction of companies explicitly addresses CE in their business processes. For these reasons, extensive literature reviews on existing approaches, methods and tools to assess CE [11,15,16] point out the potential usefulness of a more holistic assessment framework/method.

Given the above shortcomings in the field of CE assessment, the goal of our paper is to develop a new Circularity and Maturity Firm-Level Assessment tool (CM-FLAT) able to evaluate both circularity and maturity of companies while being based on a sound and transparent scientific basis. The development objectives include the fulfilment of the requirements and expected properties put forward in recent studies, e.g., [15–17].
2. Background and Research Gaps

The need to assess various dimensions of the CE is emphasized by the recent attempts of standardization bodies to develop guidelines or standards for the CE assessment. In this regard, cases in point are the International Standard Organization ISO/WD 59020 “Circular economy—Measuring circularity framework”, as well as the Italian project UNI1608856 currently under development. Research can be plainly supportive in identifying what should be specifically assessed and considered with regard to CE evaluations. In the last decade, a large number of studies have attempted:

1. to propose specific metrics or indicators for assessing CE at different levels (e.g., company, eco-industrial park, regional/national), and
2. to develop comprehensive CE assessment methods.

Both these streams of studies have been recently reviewed from different angles; among the others, the authors of [5,9,10,18] have focused on CE metrics or indicators, while [11,15,16,19,20] have targeted CE assessment methods.

Despite the intense scholarly debate on CE assessment, a common framework has not been agreed on, as clearly pointed out by Niero and Kalbar [21]. In addition, the studies on CE indicators and assessment methods do not always build upon each other; in other words, new CE assessment methods have been developed while overlooking possibly interesting results achieved in systematic research on CE metrics and indicators.

In this paper, we focus on companies as an assessment target, i.e., what is generally referred to as the micro-level. In this specific content, the background below (Section 2.1) documents the main proposals, and limitations thereof, which have led to a particularly fragmented domain. These acknowledged limitations are conducive to the research gap and the consequent objectives illustrated in Section 2.2.

2.1. Approaches, Methods and Tools for CE Assessment at the Company Level

Fonseca and colleagues [13] developed an online questionnaire-based assessment to understand the level of CE implementation in Portuguese organizations. Similar approaches based on national evaluations were also followed in [22–24] for Spanish, Basque and Italian SMEs, respectively. Here, the focus is extended to a regional perspective, and this kind of CE assessment applied to a large context is likely unsuitable for organization-based assessments. Indeed, the scope of these approaches is to gather general data and identify potential barriers to the implementation of CE, while they do not aim to guide companies towards higher CE performance levels.

Other studies focused instead on developing sectors or niche-based assessment methods, therefore explicitly defining boundaries for their application. For example, Berzi and colleagues [25] developed a method focused on hybrid scooters, while Bilal and colleagues [26] targeted the building sector in developing countries. Even if not focused on a particular industrial sector, the assessment methods introduced in [27,28] apply to specific firms only. The former addressed a peculiar list of companies; the latter targeted a specific supply chain. As a result, these bespoke methods address specific entities and are not applicable outside of their intended domain. Moreover, the exclusive use of questions with yes/no answers used in [27] might underestimate the complexity of CE at the micro-level.

Lonca and colleagues [29] proposed instead a more general “umbrella” methodology for CE assessment based on a structural decomposition of methods for assessing environmental impacts. Similarly, Mayer [30] developed a framework for a comprehensive and economy-wide biophysical assessment of a CE, based on secondary data (official statistics) on resource extraction and use, and waste flows in a mass-balanced approach.

Finally, Benz [31] proposed a company-wide CE assessment tool based on a structured approach swiveling on a review of CE indicators, on a fine-tuned conceptual modeling and on a refinement and validation process. However, as the CE literature evolves quickly, this model includes only a small fraction of the current knowledge regarding CE metrics, indicators and assessment methods.
An additional set of evaluation tools has been developed to provide companies with an indication of their CE performance and readiness. This is for example the case of the assessment method developed by the Ellen MacArthur Foundation, namely Circulytics® [32], which combines general and sector-specific indicators to measure the circularity of companies and communicate their overall score. A similar approach is also adopted by Circle Economy [33] for its Circle Assessment. The CE readiness assessment developed by the Technical University of Denmark [34] adopts an online ready-to-use assessment tool. This format allows a user-friendly experience for companies’ respondents, despite its sole focus on CE readiness.

Overall, significant efforts to develop CE assessment are also paid by practitioners, which is mirrored by the existence of many independent instruments whose validity is, however, subject to controversy due to a lack of transparency on methodologies and theoretical foundations [15]. The online-based assessments such as the one developed by Oakdene Hollins [35] are efficient in calculating an aggregate score for companies’ CE performance, but no references for the methods’ scientific reliability are available, thus potentially failing to address the multifaceted nature of CE [11]. Similar practitioner-oriented CE assessment tools based on the abovementioned Circulytics® have been developed (or applied) by corporations or large companies such as Coca Cola [36] and Enel [37].

2.2. Literature Gaps and Requirements for the Development of a Comprehensive CE Assessment Tool

The wide set of approaches, methods and tools for CE assessment proposed so far strongly diverge in terms of:

- assessment level, e.g., product (or product category), plant, company, supply chain, material;
- focus on a specific industry/country;
- developer of the method, e.g., scholars, advisory bodies, companies, and
- grounding on other methodologies developed outside the scope of CE, e.g., Life-Cycle Assessment, Material Flow Analysis [15].

Furthermore, only a limited number of papers take into adequate consideration the people or entities in charge of the use/application of the proposed approaches/tools. These altogether discourage the uptake of a single, comprehensive, and widely accepted assessment method or tool [15]. On the other hand, it has to be pointed out that analyzing a subset of CE aspects could lead to misleading interpretation of actual CE performances [38]. Walzberg and colleagues [16] questioned the need for a new (sustainability) assessment method for the CE and concluded that additional research is required in this field. Similarly, more advanced CE assessment tools are demanded in other sources [15,17].

In light of the need to develop a new tool for CE assessment at the firm level, it is worth identifying its main requirements. In this respect, the authors of [15] put forward the following properties of an ideal micro-level CE assessment tool:

1. including all three triple bottom line sustainability dimensions (or if not, at least integrating another existing tool to cover the missing dimensions);
2. strong connection with existing tools/methodologies developed outside the scope of CE, e.g., Life-Cycle Assessment;
3. either sector-specific or general with the option to adjust to the situation (dynamic and flexible);
4. tested using real world data;
5. including a detailed description to guide implementation;
6. strongly considering that end-users are strongly involved in the development process (participatory approach); and
7. easy and clear communication of the assessment outputs/results (see the fifth figure of paper [15]).

In addition to the seven properties above, while extant literature tends to mix these aspects, there is in our view a need to distinguish between
• maturity, i.e., carrying out in a systematic and documented way activities and practices laying the foundations for CE introduction; and
• circularity, i.e., the level of CE performance of a company with respect to the maximum performance that can be achieved.

The maturity of organizations in terms of CE has been also included in the standard BS 8001:2017, as reported e.g., in [39,40], while being explicitly targeted in [41,42].

The goal of our paper is therefore to develop a new CE assessment tool, the CM-FLAT, with the following characteristics:
• ability to dynamically evaluate circularity and maturity of companies;
• being based on sound and transparent theoretic and scientific basis, while encompassing environmental, social, governance and economic aspects;
• targeting the other desired properties highlighted above based on [15].

3. Methodological Development of the Proposed CE Assessment Tool

The present section documents the steps followed to develop the CM-FLAT. As the scope is to gather indications of firms’ performances across a number of metrics/indicators, the CM-FLAT is consequently developed in the fashion of a structured questionnaire. The development shown in the present section is therefore a process aimed to select metrics to be evaluated and turned into appropriate questions, articulate the questionnaire, and establish criteria to calculate scores for circularity and maturity.

3.1. Choice of a Scientific Reference for the Development of the Tool

To identify an appropriate set of aspects to be assessed, the present work builds upon a recent study, which has collected a comprehensive set of 365 micro-level CE metrics, i.e., [18]. The metrics are organized in a framework, termed circular Value Chain (cVC) framework, which includes a number of categories relevant for CE assessment. All the metrics belong to cVC categories, which, in turn, match with the companies’ organizational functions, based on Porter’s Value Chain (PVC) model (see Table 1), mostly affected by the metrics themselves. The cVC framework has been defined to capture all the relevant aspects to get a complete picture of the degree of maturity and circularity of companies.

Table 1. Circular Value Chain and Porter’s Value Chain categories for the classification of the questions inside the CM-FLAT [18].

| Circular Value Chain (cVC) Categories | Porter’s Value Chain (PVC) Categories |
|--------------------------------------|---------------------------------------|
| Strategy & vision                    | Firm infrastructure                   |
| Business model                       |                                       |
| Environmental management             |                                       |
| Cooperation & industrial symbiosis   |                                       |
| Training                             |                                       |
| Employee satisfaction & participation| HR management                         |
| Ecodesign                            | Technology development                |
| Supplier selection & auditing        | Procurement                           |
| Direct logistics                     | Inbound & outbound logistics          |
| Reverse logistics                    |                                       |
| Resource consumption                 | Operations                            |
| Waste management                     |                                       |
| Resource recovery                    |                                       |
| Marketing & communication            | Marketing & sales                     |
| Green products performances          |                                       |
| Post-sales services                  | Service                               |
Basing the development of the CM-FLAT on a recent systematic review and the cVC framework allowed us to ensure a scientific basis and to comply with comprehensiveness requirements, at least in terms of the organizational functions involved in activities CE impacts on.

3.2. From Metrics to Questions

Metrics belonging to the cVC framework to be included as inputs for the formulation of the questions of the CM-FLAT were initially selected according to the following criteria:

- ensuring adequate gathering of information about circularity and maturity across all cVC categories;
- avoiding the collection of redundant information; in case of similar metrics, those easier to evaluate and more widely accepted, i.e., cited in more scientific publications (data made available in [18]), were preferred. This action was considered necessary in light of the large number of metrics available, 365 as mentioned above. However, in the first version of the questionnaire, a limited number of metrics were excluded as comprehensiveness was initially prioritized (see Section 4).

The next step required the transformation of the metrics into questions to verify their evaluation or level of attainment. Questions can be found in the column C of the Supplementary Material. There, questions and answers are coded, as well as they are matched with maturity or circularity, and attributed of the corresponding cVC and PVC categories.

In their original formulation, the selected metrics were inherently expressed in terms of different kinds of variables, i.e., continuous, discrete and dummy. To target usability and avoid the need for detailed, and difficult to get, data to answer questions, it was decided to introduce no open-ended questions in the CM-FLAT. As a result, both quantitative and qualitative questions were assigned corresponding answers expressed in ordinal scales; questions potentially requiring quantitative answers included a predefined range of values. Scales and definitions of attainment levels were adopted from scientific or other authoritative sources whenever possible, namely [43–54].

As a further measure to enhance user friendliness, the provision of some questions was structured into matrices where respondents can provide several data concerning specific areas of investigation simultaneously. This is for example the case of environmental management (see rows 174–207 in the Supplementary Material), where a matrix containing a list of practices is presented to the respondent in a single question, and yes/no answers are sufficient to indicate the presence or the absence of these practices in the company. In this way, the number of questions was reduced without dramatically affecting the coverage of CE aspects required for assessment scopes. Definitions of some concepts were given to support respondents with little to no previous knowledge in the field of CE, see additional notes in the column D of the Supplementary Material.

3.3. From Answers to Circularity and Maturity Scores

Scores were then attributed for each question or subquestion (in case of matrices of questions) based on the answer given. In some cases, reference was made to criteria of scores’ attribution already available in the literature, e.g., scores for waste management are in line with [55]. Each question-related score participated in the computation of a specific overall score for circularity or maturity in one of the cVC categories, as inferable from the columns G and J of the Supplementary Material.
The CM-FLAT was designed to be used by companies regardless of their peculiarities, e.g., size, industry, products/production processes, and country. To ensure the greatest flexibility, an adaptive branching mechanism was introduced, governed by the dependence of certain questions on the answers of previous questions, introducing the concept of “predecessor”. An example of a predecessor is given in row 109 of the Supplementary Material, which shows that the question 14 is asked just if the answer 13b has been given. Markedly, it was foreseen that some questions would have made sense just in particular circumstances to be verified prior to posing them. There are two main general cases in which the branching mechanism was considered particularly appropriate, which however impact on the score differently.

- Inapplicable conditions: for instance, if a company does not produce solid waste, all the questions concerning solid waste management, reuse and recycling do not make sense; as for corresponding circularity and maturity scores, those are not penalized by inapplicability conditions.
- Absence of performances: if a company does not implement any environmental-oriented policies, it is useless to ask further details on the topic, otherwise relevant in other circumstances. In this case, the score is penalized by this answer.

At the end of this process, the first version of the questionnaire comprised 73 thematic questions targeting one or more CE metrics. Out of these, 23 related to the maturity of the company towards CE and 50 to the circularity of its actions. In addition, four questions addressed general information about the company such as sector, prevalent business model (B2B, B2C, etc.) and affiliation to sustainable related associations, bringing the total to 77 questions (Figure 1). We would like to point out that, for the sake of simplicity, the final version only is fully provided (see Supplementary Material for explanations).

### Figure 1.

Number of questions included in the first version of the CM-FLAT, subdivided into cVC and PVC categories; the latter are distinguished by color. The sizes of cVC-related rectangles are proportional to the number of included questions. The numbers indicate the quantity of questions targeting one or more CE metrics.

#### Operations
- Resource recovery 0, 15
- Resource consumption 2, 4

#### Firm Infrastructure
- Waste mgmt 2, 7

#### Technology development
- Business model 0, 6
- Coop & ind symbiosis 3, 1
- Ecodesign 1, 11

#### In & out logistics
- Direct logistics 2, 2
- Reverse logistics 1, 2
- Marketing & sales
- Marketing & comm 2, 1
- GP 0, 1
- Employee sat & part 2, 0
- Training 1, 0
- Supplier sel & auditing 3, 0

3.4. Reporting

The adaptability of the CM-FLAT, and markedly the branching mechanism, was ensured by adopting an online tool, which can be currently accessed and handled by the authors only at the present stage. The online tool facilitated the development of a case-based scoring system. The automatic scoring system is based on the evaluation of the
single answers as well as the interaction between different answers in the assessment. The latter feature was introduced to crosscheck the answers and to make sure that no under- or over-performance is reported to the respondents, e.g., sum of resources’ recovery practices exceeding 100%. To simplify the interpretation of the assessment outputs, a radar chart was used as a means to convey the results to the respondents. The example in Figure 2 was built through random answers for illustration scopes. As mentioned, the cVC categories were used to achieve a plurality of circularity and maturity scores (Figure 2a,b, respectively), which clearly indicate areas for improvement. Having disaggregated information at this level of detail supposedly helps companies to get an effective picture of the company’s situation and to target improvement measures to areas of greatest deficiency and strategic interest. The performance values were given as a percentage of the maximum value achievable by the company in a given cVC category, taking into account inapplicable metrics as described above. The maximum is a theoretical optimum that does not consider the average performance of the sector or any technological or regulatory limitations. When cVC circularity or maturity categories are not applicable to the specific case study (e.g., as a consequence of the branching mechanism and specific answers), the corresponding dot is omitted (see some examples in Section 5). In this way, the inapplicability is not confused with missing performances for such categories. Information on these aspects is added in the report in the form of notes, so that companies using the CM-FLAT can still take them into account.

![Circularity performance](image1.png) ![Maturity performance](image2.png)

**Figure 2.** CE assessment outputs summarized with a radar chart for the overall company’s performance in terms of circularity (a) and maturity (b) for the categories relevant to a company (randomly answered questions).

In addition, the CM-FLAT is capable of generating a complete summary of the answers provided by the respondents with the corresponding calculated performance. This feature was introduced to keep track of all the answers and how those affected the circularity and maturity scores.

### 3.5. Summary of Design Choices to Fulfil the Requirements for the CM-FLAT

In light of the development process, we summarize below the actions, choices and measures taken in order to fulfil the major requirements presented in Section 2.

- **Comprehensiveness:** the questionnaire derives from the metrics classified in the cVC framework, with a strong reliance on a recent review.
- **Scientific soundness:** the underlying model derives from the scientific literature in the CE field.
- **Maturity and circularity:** distinct scores and differentiation of categories ascribable to maturity and circularity, which are enabled by the automatic scoring system.
• Adaptability/flexibility: ensured by the branching mechanism, influencing the score algorithm.
• Usability: from the point of view of information acquisition, it presents a limited number of questions and answers’ options despite a large coverage of important areas to be considered in CE assessment; definitions and explanations are present, reports are complete and enriched by graphical elements.

4. Validation and Fine-Tuning of the CE Assessment Tool

4.1. Methodological Approach for and Overview of the Validation Process
The validation process was carried out following the three-stage validation process introduced in [56] and summarized as follows.

1. Self-validation: The first step in the validation process consisted in the gathering of authors’ feedback. An opinion was expressed by each author in full autonomy on an initial draft and later discussed during team meetings. In this way, no team member was biased by other authors and the review process was carried out upon unanimous agreement. The purpose of this phase is: (a) to foster internal alignment on the purpose and structure of each question and answer and on the effectiveness of the questionnaire as a whole; (b) to present each question and answer in a documented and simple way in order to have the highest communicative effectiveness towards respondents and other stakeholders.

2. Experts’ validation: A pool of seven experts was selected by choosing people from both universities and research institutes (5) and consultancy/industry (2). The inclusion criteria were a documented and plurennial experience in the field of CE. This ensured the soundness of this second validation stage. Feedback was gathered from each expert to establish modification actions. The main purpose of this phase is to ensure objectivity through independent expert judgement.

3. Companies’ validation: The final validation stage was conducted by selecting a group of six companies of different sizes and sectors. A complete assessment through the final version of the CM-FLAT was conducted together with companies’ representatives and feedback was gathered directly from the respondents in an oral form. Including companies, which are the final recipients of the CM-FLAT, in the final validation and refinement phase makes it possible to keep the highest possible level of transparency of the tool itself, as well as to test its usefulness and usability with final users. In addition, this allowed us to fulfill one of requirements proposed in [15], i.e., testing our proposal with real data.

The combination of self, experts’ and companies’ validation made it possible to evaluate the consistency of the instrument with the CE paradigm, as well as to understand how companies perceive a questionnaire-based assessment. The different validation stages and the main changes made to the CM-FLAT throughout its refinement are documented in the following subsections. Overall, the most remarkable modification led to enhancing the clarity of the questions, reducing the number of questions through further grouping them into matrices, eliminating some metrics because of too subtle differences with other ones and diffused disagreement on them being considered as qualifiers of CE. This applied notably to circularity-oriented metrics and questions, as inferable from the comparison of Figures 1, 3 and 4.
Figure 3. Number of questions included in the second version of the CM-FLAT. The interpretation of the diagram follows the indications given in the caption of Figure 1.

Figure 4. Number of questions included in the third and in the last version of the CM-FLAT. The interpretation of the diagram follows the indications given in the caption of Figure 1.

4.3. Experts’ Validation and Third Version of the Tool

Each of the seven experts were provided with the questionnaire in a spreadsheet format similar to the Supplementary Material. All questions, predecessors, categories and scores were therefore made available. The questions listed in the spreadsheet were ordered according to their expected sequence; obviously, questions with predecessors could be skipped based on previous answers. The material provided made it possible to gather specific feedback on questions, corresponding answers, and the overall flow and consistency of the questionnaire.

Feedback was then analyzed and grouped if addressing similar issues. As for common problems, the excessive length of the questionnaire was mentioned by four experts.

4.2. Self-Validation and Second Version of the Tool

After the revision conducted by the authors in the self-validation phase, the CM-FLAT included 63 questions, with 32 of them evaluating circularity, 26 maturity and the remaining four used for obtaining information of general relevance to be used as predecessors. Each category is featured by at least one question (Figure 3). Due to the presence of matrices, as recalled in Section 3.1, the number of metrics useful for the scoring was nevertheless higher than the number of questions. This condition is plainly shared by all versions of the questionnaire.
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Feedback was then analyzed and grouped if addressing similar issues. As for common problems, the excessive length of the questionnaire was mentioned by four experts. The same number of comments arose with regard to potentially ambiguous words such as “green”, “circular”, “ecodesign”. Reformulation of questions/answers and more exhaustive definitions were the measures taken to overcome this issue. Less frequent issues concerned language and/or grammar imperfections, and pertinence of some environmental management practices with CE. It is worth noting that no negative comments regarding general form, content and scientific foundation of the CM-FLAT were expressed by the involved experts. Overall, 37 total potentially addressable comments were gathered and 11 corrective actions were implemented.

After the experts’ validation, the number of questions was reduced to 45 in virtue of the possibility of further incorporating multiple aspects in a question. Furthermore, a reduction in the number of questions was achieved by simplifying the questionnaire removing questions whose answers could be determined through other questions. In the so-achieved third version, which underwent a consensus process by the authors, out of the 45 questions:

- four were meant to gather general information,
- 15 were aimed at measuring companies’ circularity,
- the remaining 26 were focused on companies’ maturity towards CE.

The achieved distribution of questions among the categories of the framework is summarized in Figure 4.

4.4. Companies’ Validation and Final Version of the Tool

The last step of the validation process involved six Italian companies working in different fields, which were selected as a sample of convenience for a pilot study. The companies are characterized by different features, as summarized in Table 2.

Table 2. Summary of the main characteristics of the companies used as case studies for the third stage validation of the CM-FLAT.

| Case study 1 | Machining | 43 | Business partner and manager | 74 |
|--------------|-----------|----|-------------------------------|----|
| Case study 2 | Post-harvest activities | 180 | CEO | 56 |
| Case study 3 | Post-harvest activities | 92 | Brand and communication B2B | 46 |
| Case study 4 | Manufacture of construction products | 34 | Consulting, sales, customer service | 46 |
| Case study 5 | Online sale of products for children and adults | 2 | Employee | 48 |
| Case study 6 | Business consulting services for the textile industry | 5 | Business partner and manager | 58 |

1 Statistical classification of economic activities in the European Community (https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF, accessed 10 April 2021) (NACE).
Companies were firstly contacted and briefly presented with the CM-FLAT, its presumed advantages and the means by which it is carried out, i.e., a structured interview where the questionnaire is compiled with the help of one of the authors. Despite the end goal of developing a self-assessment tool, the choice was to carry out the case studies through structured interviews in order to have an immediate feedback from the respondents and promptly individuate potential issues in the CM-FLAT. No particular constraints were posed as for the involved respondents inside the organization; however, we strongly suggested the presence of an executive due to their typical company-wide overview.

Any comments directly and indirectly emerging from the interviews were noted by the interviewers to draw potential changes to the CM-FLAT. After each interview, the answers were used to feed the scoring algorithm, which automatically analyzed them and generated the final report. Companies were then individually contacted to present them the report with their overall circularity and maturity performance. This last step made it possible to obtain additional feedback from the respondents to fine-tune the CM-FLAT.

The main remarks made by the interviewees concerned the supposed irrelevance of certain aspects previously participating in the determination of the score. An additional important point that was modified regarded questions on the flows of material in input and output, which have been addressed in recently introduced standards or regulations. It followed that the previous formulation of some of these questions looked obsolete. Nevertheless, the changes made did not affect the number of questions included in the CM-FLAT, nor the distribution thereof among circularity and maturity, as well as across cVC categories. As aforementioned, the final version of the CM-FLAT is available in the Supplementary Material (file CM-FLAT.xlsx).

Yet, despite the changes, the data collected were sufficient for recalculating scores of the companies interviewed at the beginning of the process, hence before the final modifications. These companies were duly informed, and they received an updated report.

5. Examples of the Application of the CE Assessment Tool and Discussion

5.1. The Maturity and Circularity Assessment Tool for Companies

The multi-stage validation resulted in a version of the CM-FLAT that was perceived by respondents as a good compromise between the efforts required to carry out the assessment and its potential usefulness. The appropriateness of the completion time, the degree of detail of the information requested, and the completeness of the company’s situation as a whole were the main objects of discussion between the authors and company representatives. While the number of companies involved is too limited to draw general conclusions, it is considered sufficient for a pilot study and to evaluate the applicability of the CM-FLAT. By the way, the aim of the paper is not to present general results in terms of maturity and circularity for companies in a specific territory, rather to draw conclusions on the potential and usefulness of the CM-FLAT.

However, interesting examples of CM-FLAT outputs are reported. The insights gained by the interplay between circularity and maturity outcomes might be representative of diffused situations in the industry.

The company referred to in Figure 5 is a SME that does not prioritize CE yet, but it is very focused on the innovation of management and production processes. In this case, high values of circularity and maturity (Figure 5a,b, respectively) correspond to practices adopted for legislative reasons, market drives, economic convenience, and sensitivity of the corporate culture. This demonstrates how companies that are alert to industrial trends and managed in a far-sighted manner can become the fulcrum for virtuous change in the productive system of a territory or a sector. In this specific case, environmental management regulations (in particular quality standards and waste management) give clear indications on various environmental aspects of the CE. Another interesting result of this case study is that regulations are not always favorable to circular actions. In this context, for example, product quality standards limit the amount of incoming material...
from recycling, thus influencing the performance for the categories “Reverse logistics” and “Ecodesign on materials”.

The company referred to in Figure 6 is completely different in terms of sector, size, and management practices. The most interesting aspect, however, concerns the fact that the company in question has a great maturity and awareness of environmental and sustainability issues. It is currently involved in innovation in this field, also collaborating with other companies. This emerges from the high scores obtained for the Strategy and vision, Ecodesign and Cooperation categories (Figure 6b). The interview was useful to improve some points in the questionnaire and to grasp some differences and peculiarities of the CE with respect to environmental sustainability in a broader sense. In this respect, environmental management and material and waste flows scored very well, while the more specific questions on CE alone received the lowest scores (Figure 6a).

**Figure 5.** Example of results: company with no previous experience in CE practices. The circularity (a) and maturity (b) categories that do not present a dot are not applicable to the specific case study, which has been revealed by the branching mechanism (e.g., business model and waste management for circularity).

**Figure 6.** Example of results: company with previous experiences in sustainability practices and assessments. Categories within circularity (a) and maturity (b) with missing dots to be interpreted in line with the caption of Figure 5.
5.2. Further Evidence Achievable from the Reports

The ultimate aim of the CM-FLAT is to increase companies’ awareness of viable practices targeting CE, and to take improvement actions accordingly. To this aim, the final phase of returning the results to the company is of fundamental importance. After building the CM-FLAT on a solid scientific basis and validating the algorithms behind it, the usefulness for companies depends on usability, i.e., the ability to effectively communicate the results obtained. From the interviews conducted, the feedback on this aspect was positive, as aforementioned. In general, the time needed to answer the questionnaire is less than an hour. In cases where the interviews lasted longer, the respondents described some of the practices they had adopted or commented on the questionnaire while completing it.

We noted that companies that did not consciously have a CE culture in place or were in the process of doing so were more willing to test the tool and willing to discuss results. Very interesting considerations emerged, particularly when comparing maturity and circularity. Circular actions are implemented by companies, even with low maturity, for several reasons. The main reasons concern waste management, which—particularly in some sectors—is extremely virtuous in a circular perspective, driven by sector regulations and cost cutting (e.g., packaging reduction). Other actions, such as the reduction of plastic in the company (e.g., replacing packaged water with tap water devices) or the choice of suppliers with an eye to their environmental performance, depend on the company management, and were also found in companies with medium to low maturity in terms of CE.

These results make it possible to confirm the usefulness of keeping the concepts of maturity and circularity separate. This gives companies a complete overview of the level they are at, immediately highlighting which aspects could be improved. Indeed, the actions to be taken are very different depending on whether the intervention concerns business models, design, waste management, company culture, etc.

The importance of distinguishing maturity and circularity is stressed in Figure 7, which shows the result of the overall performance assessment (maturity and circularity) for two of the test companies (Figure 7a,b, respectively). Here, all the scores were summed without any weighing irrespective of their belonging to maturity and circularity in the CM-FLAT. These two companies obtained very similar total scores (48 and 50% out of the maximum achievable), but as can be seen from the graphs (Figure 7a,b), they resulted from a different distribution of performances. It follows that for the companies a. and b., information on their maturity and circularity performance in the different aspects of cVC represents added value for business decisions.

![Circular economy performance](image)

**Figure 7.** Example of results where maturity and circularity are not distinguished for two different companies (a) and (b). Missing dots to be interpreted in line with the caption of Figure 5.
5.3. Additional Remarks

While the CM-FLAT has been developed and streamlined to evaluate CE performances of companies, some firms agreed with the interviewers on changing the focus of analysis. Markedly, a company asked to analyze a specific production line, which was intended to undergo major changes in the short term with an eye on targeting CE objectives. This would allow the company to compare the attainment of CE objectives if the CE assessment tool will be used again after the reorganization of the mentioned production line. Similarly, a company focused on a specific product they develop, which is considered as a case in point in terms of sustainable design and manufacturing. Moreover, another company decided to focus on a whole supply chain, which was supposed to highlight virtuous sustainable practices better than if the specific firm were analyzed in isolation. All these examples, where the application of the CM-FLAT was possible and successful, mark its flexibility beyond our intended scopes.

Some companies added comments in terms of the alignment of the scores received with their expectations. While there was a general consensus on the presented CE performances, in a few cases expectations were higher. This was due to the fact that organizations establish sustainability targets, but those are not always in line with CE objectives, which we formally considered because of building the CE assessment tool starting from acknowledged CE metrics. This aspect might well contribute to boost the scientific discussion on nuances of misalignment between sustainability and CE perspectives, e.g., [57]. This also complicates the matters in terms of fulfilling one of the requirements for CE assessment tools laid bare in [15], namely linking CE assessment with more consolidated sustainability assessment methods. Actually, we claim that the CM-FLAT fulfils all expected requirements except for this one.

6. Conclusions

The starting point of the present research was an observed lack of consistency between CE micro-level metrics and existing CE assessment frameworks. Despite the increasing number of assessment models developed by scholars and practitioners, a low adoption of circular practices is still highlighted by most studies [9–11]. One of the reasons behind this fact could be the perception companies might have regarding a concept that is still evolving, hence its dubious definition and benefits. This urges the development of new CE assessment methods that can simplify the first interaction businesses might have with CE and its scopes, thanks to the following characteristics:

- they do not require a significant amount of resources (whether money or time);
- they are able to adapt themselves to different contingency factors such as company size, industry, starting circularity and maturity levels;
- they do not focus on a single aspect of CE and try to maximize the assessed aspects of CE in a limited number of questions;
- they are tailored for companies, i.e., they target the micro-level specifically;
- they provide respondents with a clear and effective indication of their starting performance levels and allow a quick identification of critical points, thus suggesting potential priorities in defining corrective actions.

Although some of the existing CE assessment models might satisfy one or more of the above requirements, a critical missing feature concerning most of them is the lack of a sound and transparent scientific basis and validation. Being based on a structured literature review and a multiple stages validation process, the CM-FLAT, i.e., the CE assessment tool presented in this work, is believed to be a useful tool for companies willing to boost their CE performance, and/or introduce CE-oriented business models, products and processes. In relation to the trend of introducing standards about CE and practices therefor, as mentioned in Section 2, the CM-FLAT represents a useful instrument to verify the fulfillment of requirements, and, consequently the possibility to obtain certifications. This is nevertheless restricted to companies, i.e., the focus of the CM-FLAT. It is also worth
noting that the usefulness of the CM-FLAT in this regard will be increased if the standards under development will decide

- to include a comprehensive number of CE-related aspects (here the proposed scheme of the circular Value Chain is particularly pertinent), and
- to consider the scientific research on CE as the reference for selecting relevant CE metrics and indicators.

One of the main objectives was to develop a questionnaire that could represent a satisfactory trade-off between the effort made by the respondents to answer and the information provided upon the questionnaire’s completion. Positive feedback was gathered in the last validation step in this respect. The balance between completion time and completeness of the assessment was also crucial in the development phase since it represented a critical point for the scalability of the assessment.

Future work includes the transformation of the present version of the CM-FLAT into a freely accessible web application. This action would allow the unsupervised use of the CM-FLAT, which could lead to the gathering of a much larger number of data about circularity and maturity. Eventually, this would make it possible to launch a large-scale campaign and gather evidence of the overall CE performances of firms operating in specific sectors and geographical areas. In addition, a large number of outcomes in terms of maturity and circularity could lead to the definition of typical industrial situations, to be addressed by similar measures and initiatives with the aim to move towards the CE.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su13095288/s1. In the Supplementary Material (file CM-FLAT.xlsx), the final version of the CM-FLAT is presented. Markedly, each question (column C) includes a code (column A), the presence of a predecessor in the format of one or more answer codes (column B), additional notes including explanations presented to interviewees (column D), corresponding category (both cVC and PVC in columns H and I, respectively), the reference to maturity or circularity (M/C, empty for general purpose questions, column J), the possible reference to a scale from the literature (column K). For each question, column E presents the codes associated to each possible answer, fully reported in column F, along with the associated score in column G.

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References

1. Bressanelli, G.; Saccani, N.; Pigosso, D.C.; Perona, M. Circular Economy in the WEEE industry: A systematic literature review and a research agenda. Sustain. Prod. Consum. 2020, 23, 174–188. [CrossRef]
2. Centobelli, P.; Cerchione, R.; Chiaroni, D.; Del Vecchio, P.; Urbinati, A. Designing business models in circular economy: A systematic literature review and research agenda. Bus. Strategy Environ. 2020, 29, 1734–1749. [CrossRef]
3. Jia, F.; Yin, S.; Chen, L.; Chen, X. The circular economy in the textile and apparel industry: A systematic literature review. J. Clean. Prod. 2020, 259, 120728. [CrossRef]
4. Saidani, M.; Yannou, B.; Leroy, Y.; Cluzel, F.; Kendall, A. A taxonomy of circular economy indicators. *J. Clean. Prod.* **2019**, *207*, 542–559. [CrossRef]

5. Kristensen, H.S.; Mosgaard, M.A. A review of micro level indicators for a circular economy—moving away from the three dimensions of sustainability? *J. Clean. Prod.* **2020**, *243*, 118531. [CrossRef]

6. Pesce, M.; Tamai, I.; Guo, D.; Critto, A.; Brombal, D.; Wang, X.; Cheng, H.; Marcomini, A. Circular economy in China: Translating principles into practice. *Sustainability* **2020**, *12*, 832. [CrossRef]

7. De Oliveira, C.T.; Dantas, T.E.T.; Soares, S.R. Nano and Micro Level Circular Economy Indicators: Assisting decision-makers in circularity assessments. *Sustain. Prod. Consum.* **2021**, *26*, 455–468. [CrossRef]

8. Franco, N.G.; Almeida MF, L.; Calill, R.F. A strategic measurement framework to monitor and evaluate circularity performance in organizations from a transition perspective. *Sustain. Prod. Consum.* **2021**, *27*, 1165–1182. [CrossRef]

9. Corona, B.; Shen, L.; Reike, D.; Carreón, J.R.; Worrell, E. Towards sustainable development through the circular economy—A review and critical assessment on current circularity metrics. *Resour. Conserv. Recycl.* **2019**, *151*, 104498. [CrossRef]

10. Parchomenko, A.; Nelen, D.; Gillabel, J.; Rechberger, H. Measuring the circular economy: A Multiple Correspondence Analysis of 63 metrics. *J. Clean. Prod.* **2019**, *210*, 200–216. [CrossRef]

11. Sassanelli, C.; Rosa, P.; Rocca, R.; Terzi, S. Circular economy performance assessment methods: A systematic literature review. *J. Clean. Prod.* **2019**, *229*, 440–453. [CrossRef]

12. Rincón-Moreno, J.; Ormazábal, M.; Álvarez, M.J.; Jaca, C. Advancing circular economy performance indicators and their application in Spanish companies. *J. Clean. Prod.* **2021**, *279*, 123605. [CrossRef]

13. Fonseca, L.M.; Domingues, J.P.; Pereira, M.T.; Martins, F.F.; Zimon, D. Assessment of circular economy within Portuguese organizations. *Sustainability* **2018**, *10*, 2521. [CrossRef]

14. Ngan, S.L.; How, B.S.; Teng, S.Y.; Promentilla MA, B.; Yatim, P.; Er, A.C.; Lam, H.L. Prioritization of sustainability indicators for the circular economy: The case of developing countries. *Renew. Sustain. Energy Rev.* **2019**, *111*, 314–331. [CrossRef]

15. Roos Lindgreen, E.; Salomone, R.; Reyes, G.; Terzi, S. Circular Economy at the Micro Level. *Sustainability* **2020**, *12*, 4973. [CrossRef]

16. Walzberg, J.; Lonca, G.; Hanes, R.; Eberle, A.; Carpenter, A.; Heath, G.A. Do we need a new sustainability assessment method for the circular economy? A critical literature review. *Front. Sustain.* **2021**, *1*, 620047. [CrossRef]

17. Saidani, M.; Yannou, B.; Leroy, Y.; Cluzel, F. How to assess product performance in the circular economy? Proposed requirements for the design of a circularity measurement framework. *Recycling* **2017**, *2*, 6. [CrossRef]

18. Elia, V.; Gnoni, M.G.; Tornese, F. Measuring circular economy strategies through index methods: A critical analysis. *J. Clean. Prod.* **2017**, *142*, 2741–2751. [CrossRef]

19. Harris, S.; Martin, M.; Diener, D. Circularity for circularity’s sake? Scoping review of assessment methods for environmental performance in the circular economy. *Sustain. Prod. Consum.* **2021**, *26*, 172–186. [CrossRef]

20. Niero, M.; Kalbar, P.P. Coupling material circularity indicators and life cycle based indicators: A proposal to advance the assessment of circular economy strategies at the product level. *Resour. Conserv. Recycl.* **2019**, *140*, 305–312. [CrossRef]

21. Ormazabal, M.; Prieto-Sandoval, V.; Jaca, C.; Santos, J. An overview of the circular economy among SMEs in the Basque country: A multiple case study. *J. Ind. Eng. Manag.* **2016**, *9*, 1047–1058. [CrossRef]

22. Ormazabal, M.; Prieto-Sandoval, V.; Puga-Leal, R.; Jaca, C. Circular economy in Spanish SMEs: Challenges and opportunities. *J. Clean. Prod.* **2018**, *185*, 157–167. [CrossRef]

23. Mura, M.; Longo, M.; Zanni, S. Circular economy in Italian SMEs: A multi-method study. *J. Clean. Prod.* **2020**, *245*, 118821. [CrossRef]

24. Berzi, L.; Delogu, M.; Pierini, M.; Romoli, F. Evaluation of the end-of-life performance of a hybrid scooter with the application of recyclability and recoverability assessment methods. *Resour. Conserv. Recycl.* **2016**, *108*, 140–155. [CrossRef]

25. Bilal, M.; Khan KI, A.; Thaheem, M.J.; Nasir, A.R. Current state and barriers to the circular economy in the building sector: Towards a mitigation framework. *J. Clean. Prod.* **2020**, *276*, 123250. [CrossRef]

26. Ioannou, E.; Hanekroot, L.; Reijngoud, A. Benchmark Circular Business Practices 2015. 2016. Available online: https://www.circulairondernemen.nl/uploads/79a8b3ab7126a391674b6207b75153f7.pdf (accessed on 10 April 2021).

27. Masi, D.; Kumar, V.; Garza-Reyes, J.A.; Godsell, L. Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. *Prod. Plan. Control* **2018**, *29*, 539–550. [CrossRef]

28. Lonca, G.; Muggêrô, R.; Têreault-Imbeault, H.; Bernard, S.; Margni, M. A bi-dimensional assessment to measure the performance of circular economy: A case study of tires end-of-life management. In *Designing Sustainable Technologies, Products and Policies*; Springer: Cham, Switzerland, 2018; pp. 33–42.

29. Mayer, A.; Haas, W.; Wiedenhofer, D.; Kraussmann, F.; Nuss, P.; Blengini, G.A. Measuring progress towards a circular economy: A monitoring framework for economy-wide material loop closing in the EU28. *J. Ind. Ecol.* **2019**, *23*, 62–76. [CrossRef]

30. Benz, Measuring the Circular Economy. Developing a Circular Economy Assessment for Company Level. Utrecht University. 2019. Available online: https://dspace.library.uu.nl/handle/1874/379822 (accessed on 10 April 2021).
32. Ellen MacArthur Foundation. Circulytics—Measuring Circularity. Circulytics™ Is the Most Comprehensive Circularity Measurement Tool for Companies. 2017. Available online: https://www.ellencircularity.org/resources/apply/circulytics-measuring-circularity (accessed on 10 April 2021).

33. Circle Economy. Circle Assessment. 2016. Available online: https://www.circle-economy.com/digital/circle-assessment (accessed on 10 April 2021).

34. McAloone, T.C.; Pigosso, D.C.; Perrild, L.S. Making the Transition to Circular Economy through readiness assessment. In Sustain; Technical University of Denmark: Kongens Lyngby, Denmark, 2017; p. G-10.

35. Oakdene Hollins. Towards a Circular Economy–Waste Management in the EU; Science and Technology Options Assessment: Brussels, Belgium, 2017. Available online: https://www.oakdenehollins.com/reports/2017/10/18/towards-a-circular-economy-waste-management-in-the-eu (accessed on 10 April 2021).

36. Grace, R. Closing the Circle: Reshaping How Products are Conceived & Made: Ideo & Ellen MacArthur Foundation create an outline for a New Plastics Economy & launch a Circular Design Guide to help. Plast. Eng. 2017, 73, 8–11.

37. Tagliaferro, N. The Circular Economy at Enel X. Symphonya. Emerg. Issues Manag. 2020, 1, 101–116.

38. Helander, H.; Petit-Boix, A.; Leipoldt, S.; Bringezu, S. How to monitor environmental pressures of a circular economy: An assessment of indicators. J. Ind. Ecol. 2019, 23, 1278–1291. [CrossRef]

39. Pauliuk, S. Critical appraisal of the circular economy standard BS 8001: 2017 and a dashboard of quantitative system indicators for its implementation in organizations. Resour. Conserv. Recycl. 2018, 129, 81–92. [CrossRef]

40. Rossi, E.; Bertassini, A.C.; dos Santos Ferreira, C.; do Amaral WA, N.; Ometto, A.R. Circular economy indicators for organizations considering sustainability and business models: Plastic, textile and electro-electronic cases. J. Clean. Prod. 2020, 247, 119137. [CrossRef]

41. Ávila-Gutiérrez, M.J.; Martin-Gómez, A.; Aguayo-González, F.; Córdoba-Roldán, A. Standardization framework for sustainability from circular economy 4.0. Sustainability 2019, 11, 6490. [CrossRef]

42. Haezendonck, E.; Van den Berghe, K. Patterns of Circular Transition: What Is the Circular Economy Maturity of Belgian Ports? Sustainability 2020, 12, 9269. [CrossRef]

43. Harris, K. Use a Maturity Model to Make the Most of e-Learning; Gartner Research Note DF-22; Gartner Inc.: Stamford, CT, USA, 2014; Volume 3036.

44. Mehta, N. The value creation cycle: Moving towards a framework for knowledge management implementation. Knowl. Manag. Res. Pract. 2007, 5, 126–135. [CrossRef]

45. Pee, L.G.; Kankanhalli, A. A model of organisational knowledge management maturity based on people, process, and technology. J. Inf. Knowl. Manag. 2009, 8, 79–99. [CrossRef]

46. Luftman, J.; Brown, C.V.; Balaji, S. Customer–Provider Strategic Alignment: A Maturity Model. In Service Systems Implementation; Springer: Boston, MA, USA, 2011; pp. 145–163.

47. Pigosso, D.C.; Rozenfeld, H.; McAloone, T.C. Ecodesign maturity model: A management framework to support eodesign implementation into manufacturing companies. J. Clean. Prod. 2013, 59, 160–173. [CrossRef]

48. Antunes, P.; Carreira, P.; da Silva, M.M. Towards an energy management maturity model. Energy Policy 2014, 73, 803–814. [CrossRef]

49. Golev, A.; Corder, G.D.; Giurco, D.P. Barriers to industrial symbiosis: Insights from the use of a maturity grid. J. Ind. Ecol. 2015, 19, 141–153. [CrossRef]

50. Ellen MacArthur Foundation. Waste Not, Want Not. Capturing the Value of the Circular Economy through Reverse Logistics. An Introduction to the Reverse Logistics Maturity Model. 2016. Available online: https://www.ellencircularity.org/assets/downloads/ce100/Reverse-Logistics.pdf (accessed on 10 April 2021).

51. Ormazabal, M.; Sarriejg, J.M.; Viles, E. Environmental management maturity model for industrial companies. Manag. Environ. Qual. Int. J. 2017, 28, 632–650. [CrossRef]

52. Sustainable Purchasing Leadership Council. SPLC Maturity Model for Sustainable Purchasing. 2018. Available online: https://community.sustainablepurchasing.org/content/uploads/2018/01/SPLC-Maturity-Model-v17-FOR-PRINTING.pdf (accessed on 10 April 2021).

53. Yatskovskaya, E.; Srai, J.S.; Kumar, M. Integrated supply network maturity model: Water scarcity perspective. Sustainability 2018, 10, 896. [CrossRef]

54. Zucker, M. A Maturity Model for Marketing. Available online: https://www.linkedin.com/pulse/maturity-model-marketing-zucker (accessed on 10 April 2021).

55. Lansink, A. Challenging changes–Connecting waste hierarchy and circular economy. Waste Manag. Res. 2018, 36, 872. [CrossRef]

56. Cioquell-Ballester, V.A.; Cioquell-Ballester, V.A.; Monterde-Diaz, R.; Santamarina-Siurana, M.C. Indicators validation for the improvement of environmental and social impact quantitative assessment. Environ. Impact Assess. Rev. 2006, 26, 79–105. [CrossRef]

57. Kravchenko, M.; McAloone, T.C.; Pigosso, D.C. To what extent do circular economy indicators capture sustainability? Procedia CIRP 2020, 90, 31–36. [CrossRef]