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A Framework to Assess Manufacturers' Circular Economy Readiness Level in Developing Countries: An Application Case in a Serbian Packaging Company

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Abstract: Researchers highlighted the gap between the circular economy (CE) theory and real manufacturing practices. In developing countries, the background for CE development is quite different from developed countries, where there is an established waste management structure and a robust environmental policy. In addition, a shortage of best practices, guidelines, learning experiences, frameworks, and models capable of guiding manufacturers in measuring their circular level and track a roadmap towards an improvement of their circular readiness is raised in the literature. Therefore, this research develops and proposes a framework for assessing company's CE readiness and is tailored for companies operating in developing countries. In detail, the framework investigates the two main perspectives (product and business model) that companies should consider adopting and implementing CE in their operations and business. The framework also supports companies to track an improvement roadmap through the definition of future actions and KPIs. To develop the framework, an application case with a company placed in Serbia and operating in the packaging industry has been conducted. The application of the framework unveiled that there is room for improvement in developing countries to foster CE adoption, especially in the policy context. Indeed, policy incentives and instruments of public authorities would considerably support the circular transition process in companies.

Keywords: circular economy; readiness assessment; product lifecycle; manufacturing; KPI; developing country

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1. Introduction

The circular economy (CE) concept was first developed in 2005 [1] with the aim of moving from a linear product lifecycle towards a closed loop capable of replacing the disposal concept with restoration [2,3]. The European Commission (EC) in 2015 [4] defined CE as a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible, resulting in the extension of the product's life cycle and a reduction in waste to a minimum. Unlike the traditional linear economy and its make-consume-dispose approach [5], a CE takes into account the limits of the natural resources of our planet and strives to reduce the consumption of raw materials and energy by increasing the share of renewable or recyclable resources, while reducing greenhouse gas (GHG) emissions, material losses, and waste [6]. In addition, a CE contributes to economic growth, the innovation level [7], and the creation of new jobs [8].

CE has been widely applied to a heterogeneous set of industries [9–13], involving different companies traditionally belonging to linear supply chains and pushing them

to act in a circular supply chain context [14–17]. However, the adoption of CE asks for different interventions in the company (from a structural, business model [18,19], and organizational perspective [14,18], through product development [20], process optimization, and data and information management [21,22], up to the technological [23,24] and skill dimension [25]). On the other side, CE would trigger multiple benefits both internally and externally to the company's boundaries [26] and under all of the three sustainability triple bottom line perspectives (environmental, economic, and social) [27,28]. One of the most relevant industries to effectively apply CE is manufacturing [29], leading to the birth of the concept of circular manufacturing (CM) [30], defined as the concurrent adoption of different CM strategies (e.g., reuse, cleaner production, servitization), and allowing one to improve resource management, cut their consumption, and prolong and close their lifecycle loops through manufacturers' internal and external operations tailored to meet the stakeholders' needs [31]. Notwithstanding the multiple benefits occurring with the adoption of the CE paradigm, companies often do not own the needed assets, knowledge, skills, and capabilities to effectively exploit it [32]. Several methods and indexes have been detected in the literature to support companies in measuring and assessing their circularity degree [33–35]. However, a shortage of best practices, guidelines, learning experiences, frameworks, and models capable of guiding manufacturers in measuring their circular level and tracking a roadmap towards an improvement of their circular readiness is raised in the literature [21,34].

The main objective of this research is to develop a framework to assess in developing country, from the micro and macro point of view, companies' readiness to shift towards the CE paradigm and to go along a defined roadmap through the improvement of its business under different perspectives. Through an interactive research method, inspired by DRM [36], the framework, grounded on the EEA's template [8,37], was conceived and refined. Then, it was validated through an application case with a company operating in the packaging industry in Serbia (a non-EU developing country).

The packaging industry was considered since it is relevant in terms of circularity and sustainability. Plastic packaging can be especially reusable and recyclable, but packaging designers need to carefully consider the trade-offs between return rates, transport distances, difficulties, and costs in packaging sorting and cleaning. The reusability of packaging is not always the best solution. The CO_2 emissions incurred during a long-distance transport for returning and redistributing reusable packaging may have a higher negative impact on the environment [38]. In addition, the main functionalities of packaging and the protection of the enclosed products should not be jeopardized by the requirements of circularity and sustainability.

Furthermore, the research focuses on companies placed in developing countries because there is a lack of research in the literature dealing with readiness assessments of this kind of organizations to effectively embrace the CE paradigm in their business, having in mind the unregulated policy framework [39] and the lack of public instruments and measures that should fertilize a transition from linear to a circular model of economy. In particular, ref. [40] worked on developing a conceptual model to measure the change readiness for SMEs' adopting a CE, but not focusing on developed countries. Refs. [41,42] proposed a model to assess the readiness of manufacturing companies for the CE paradigm at the micro-level, in this case also not focusing on developed countries and not emphasizing the lack of a regulatory framework and support of public authorities. Ref. [43] developed a CE readiness model, composed of eight dimensions and aspects to be investigated both at micro- and macro-level (e.g., Product and Service Innovation, Manufacturing and Value Chain, Policy and Market). The model is exhaustive but the dimensions, in particular Policy and Market, could be tailored in a more specific way for companies placed in a developing country (because in such a context there are not developed regulatory frameworks for supporting circularity in the manufacturing sector, waste management at the very low level, financial support, or different financial schemes for supporting circularity, etc.). Indeed, according to [44], although the EU member countries are getting closer to the sustainable development goals (SDGs) created by the United Nations (UN) and about half

of the member countries seem ready to pass to circularity, the EU regulations and policies must support stronger transition towards CE. The regulations should be harmonized for all of the EU member countries. This finding indicates that, in developing non-EU countries, there exists even more need and space for public authorities' support of transition towards CE and harmonization with EU regulations and policies, justifying the need of a tailored model to assess readiness in these kind of companies.

The paper is structured as follows. The research context is described in Section 2 (arguing about the application of the CE domain in the packaging supply chain). In Section 3, the research methodology adopted is explained. The results are shown in Section 4 and discussed in Section 5. Conclusions are presented in Section 6.

2. Research Context

This section first introduces the concept of CE and its main characteristics in relation to readiness. Then, its relevance for the packaging industry is presented.

2.1. Circular Economy: The Transition and the Readiness Level

The concept of CE is complementary to the SDGs by the UN, a collection of 17 interlinked objectives designed to serve as a shared blueprint for peace and prosperity for people and the planet now and into the future [45]. They considerably contribute to the adoption of the CE concept by companies, consultancy firms, governments, non-governmental organizations or associations, and academics [46].

Some authors indicate that companies might not be interested in CE because of the increasing number of years that a product can be used and a longer lifecycle, which can cause a significant drop in their sales and revenues in the short term (and even in the medium term depending on the type of product). To cope with this situation, policies should be defined to encourage companies to extend products' life cycles to optimize the planet's resources. In addition, education, advertising, and other qualitative incentives, such as quality labels or badges that help people differentiate ecofriendly products with a longer lifespan, could be helpful for companies and should support consumers to recognize CE-driven products on the market [47].

Furthermore, support in transitioning towards a CE is necessary at each level (macro, meso, micro) [48] because national governments and agencies, industries, or companies might not have the financial resources and knowledge to implement a CE [49]. In particular, different means (subsidies, capital support, soft loans, incentives for research on the topic, or supporting innovative business models) have been proposed to promote and ease circularity adoption [50]. Among them, ref. [51], exploring the main enhancing and inhibiting factors for a progress towards circular business models, found that relevant regulations at the European level, appropriate technologies [23,52], and increasing social and environmental awareness of consumers [53–55] and managerial capabilities [11,56] are main drivers for changes. However, companies' settings determine their predisposition towards the CE paradigm.

According to [57], organizations that focus on radical innovations and balance the efforts between technical and soft aspects are more oriented towards a CE culture. They also found that analyzing the culture orientation for CE of the organization might create a sense of urgency in leaders and employees to move towards CE as a way to obtain environmental, social, and economic benefits. On the other side, ref. [58] found that corporate environmental responsibility (CER) is positively related to the readiness for moving towards a circular business model. Perceived CE drivers act as mediators, while perceived CE barriers moderate the relationship between CER and readiness for change-acting, reducing the positive effect. CER positively influences the readiness for changes in organizations.

Researchers made some first attempts to develop a CE readiness assessment tool. Ref. [43] developed a prototype composed of different levels in the organization: organizational readiness, business model readiness, market readiness, offering readiness, and operation readiness. Ref. [59] explained the readiness for CE as the organization's capability to adapt to the related emerging business strategies. The more a company is ready to adopt

a CE strategy, the more sustainable it operates and has to realize and understand its actual status in terms of CE readiness at a specific time [60]. In addition, organizations can also choose whether to be circular from an economic perspective. If they do not, they are also not sustainable. Finally, to effectively adopt CE practices in their organizations, companies need to concurrently implement CE interventions (i) bringing immediate results, dealing with what the organization already has, (ii) what needs to happen prior to the asset implementation, (iii) enabling changes (that could be existing things that need to be adapted, new things that need to be developed whether they are temporary as part of a transition as the organization designs its circular economic future, or could be new permanent things that are needed as part of that future to exist and that future that the organization wants to be a part of).

2.2. Circular Economy in the Packaging Industry

The quantity of materials used for packaging is growing continuously and in 2017 packaging waste in Europe reached a record of 173 kg per inhabitant. The aim of the EC [61] was to accelerate the reusability and recyclability of packaging on the EU market by 2030. Some of the mandatory requirements for packaging to be implemented on the EU market are that (over)packaging and packaging waste have to be reduced, and that packaging should be designed to be reused and recycled, considering restrictions on the use of some packaging materials for certain applications, reducing the complexity of packaging materials, and if it is possible to safely use some consumer goods without packaging [62].

The EC Packaging and Packaging Waste Directive (PPWD) emphasizes that packaging should protect products' integrity and consumers' health and safety; increase products' shelf-life; contribute to waste reduction; facilitate transport, efficient handling, and distribution; promote the packaged product; and provide information and convenience to consumers. Underpackaging and overpackaging should also be clarified. Underpackaging could lead to product and food waste, causing additional negative environmental, climate, and economic impacts. Measures to increase recyclability cannot jeopardize product safety and must avoid product waste. According to the PPWD, climate and environmental performance should be assessed throughout the entire lifecycle of the packaging and packaged products.

Under a CE lens, the limited ability to track all chemicals makes it difficult to control and limit combined exposure. Furthermore, for recycled single-use materials, such as paper and board which is chemically cleaned, modelling shows that even after a total stop of using a chemical (e.g., bisphenol A in receipts), it will remain in the recycled paper for an estimation of 31 years [63]. Studies show that recycled paper even accumulates persistent and hazardous chemicals [64].

3. Research Methodology

The main objective of this research is to develop a framework to assess in a developing country, from the micro and macro point of view, companies' readiness to shift towards the CE paradigm and to go along a defined roadmap through the improvement of its business under different perspectives (material input, eco-design, production, consumption, and waste recycling). To perform this, preconditions and factors that facilitate the implementation of the CE paradigm in a company operating in a developing country (outside the European Union's regulations regarding environment protection, waste management, GHG emission, etc.) have been detected. To develop the framework for assessing CE readiness in developing countries, a research process structured in three main phases (conceptualization, development, and validation) has been defined and is shown in Figure 1.

In this research we used mixed methods, including questionnaires fulfilled by a company's management, and the data presented on the websites of the surveyed company and in the company's Sustainability report, prepared according to the standards of the Global Reporting Initiative.

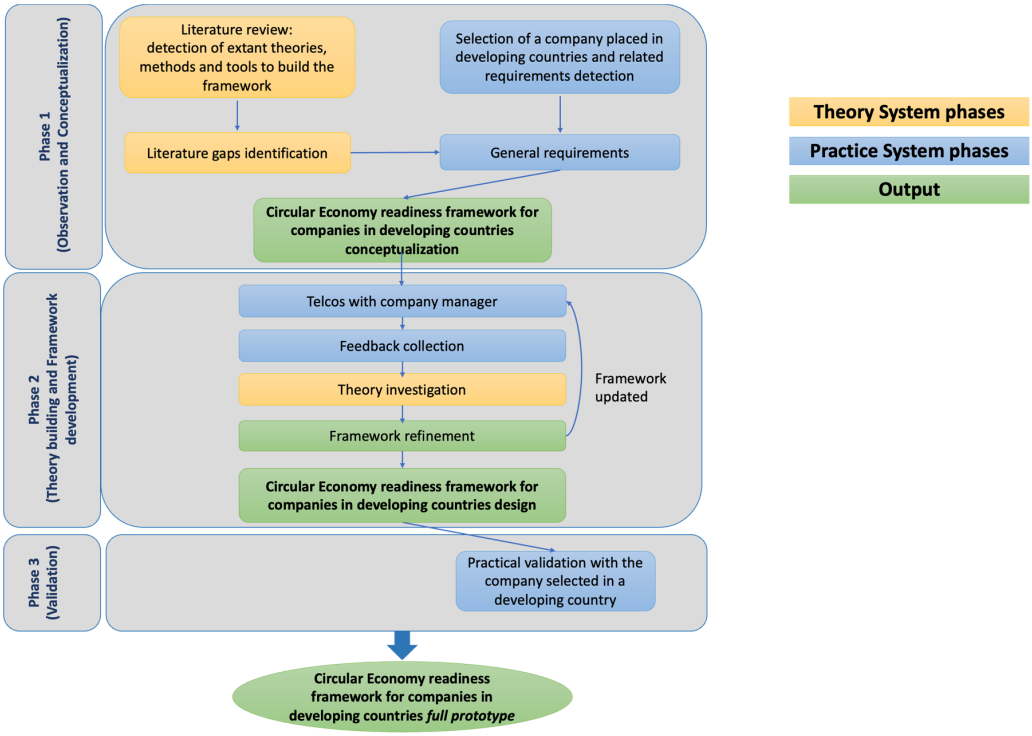

Figure 1. Research methodology adapted by [65].

3.1. Framework Conceptualization

The conceptualization phase mainly consisted of a literature review analysis. It was conducted with the Scopus database, including the following keywords: circular economy, circular economy in manufacturing, readiness, developing country. The results provided 94 documents and 4 of them were related to developing countries. The contributions were analyzed first in the title, abstract, and keywords (bringing the total to 54 contributions) and in a second round in their entire manuscript (leading to a final number of 17 papers). The main criterion used for their selection was their pertinence to the assessment of companies in terms of CE readiness. In addition, looking at the results of the literature review, it was decided to use as main reference the conceptual framework developed by the EEA for evaluating companies and their related products circularity, adjusted to the socio-economic environment of a non-EU developing country.

In addition, from the practice perspective, having in mind the increasing importance of environmental, social, and governance (ESG) issues and company's compliance to ESG standards in their operations, a company that has partly implemented CE practices in its business model and complied its activities to ESG principles was researched and detected. The main requirements of the company in terms of CE readiness were checked by triangulating the main characteristics of the EEA's framework and detecting the topics to be enhanced.

The company was chosen because of its leading role in the Serbian manufacturing industry, in terms of the responsible usage of raw materials, energy, water, reduction in GHG emission, and constant developing of employees' awareness to behave responsibly and manage resources at the workplace.

3.2. Framework and Related Protocol Development

The framework for assessing companies' readiness level in developing countries was developed based on the contributions selected with the literature review, on the EEA conceptual framework suggested by experts in the domain, and also on the requirements of the company involved in the conceptualization phase. The reason for using the conceptual framework by the EEA for this research is its comprehensiveness and cross section of

the most important aspects of circularity, as well as an overview of elements that can be assessed for measuring progress towards product circularity. A questionnaire to be fulfilled by the company's management was also integrated.

Enriching the EEA conceptual framework, some new features were added to the framework based on the feedback received during this phase after conducting some telcos and showing the framework prototype to the company sustainability manager involved in this research. Indeed, to measure company circularity readiness, a Likert scale and two radar charts were used and integrated with the EEA framework structure.

3.3. Framework Validation: The Application Case

To validate the framework, it was applied to the company already involved during the conceptualization phase. The questionnaire was fulfilled by the company's manager for sustainability and her assistant. First, the researchers read the documentation produced by the company about sustainability topics (the Yearly Sustainable Report of the last two years and the SDG Progress Report). Then, a meeting with the sustainability manager and her assistants was organized to discuss the topic introduced in the reports and to make the company's employees familiar with the research framework proposed in this research. Two weeks later, a workshop was conducted for interviewing them through the framework and gathering their answers in a form. Finally, the researchers analyzed in the back office the answers gathered and assigned them a score to obtain a final result about the company readiness in terms of both the product and business model. Finally, a last workshop was organized to discuss the results with the company employees.

In this research, a five-point Likert scale was used to measure and to express the attitudes of respondents about a certain phenomenon. Indeed, the attitudes were measured by adding numbers to certain characteristics of the observed phenomenon and then scaling was carried out. The phenomena were positioned on a certain scale depending on how many characteristics the variables had, determined via a five-point Likert scale. The respondent (in the case conducted, the Sustainability manager) had to express the degree of agreement or disagreement for each individual statement on a five-point scale (1. "Strongly disagree", 2. "Disagree", 3. "Undecided", 4. "Agree", 5. "Strongly agree"). Each respondent's answer was scored, and then by calculating the average value of the points for each statement, a total score expressing the respondent's attitude was obtained.

The Company: Bosis

The family company *Bosis* (Valjevo, Serbia) was founded in 1982 as a small craft shop for screen printing, and today is a leading manufacturer of printed and laminated cardboard packaging and blister cardboard with 143 employees. Their portfolio assortment consists of both printed and laminated cardboard packaging and blister cardboard for nearly 200 satisfied clients. Caring for their employees, the environment, and the local community is exactly what makes a company recognizable not only on the domestic and regional market but also on the EU one. The owners and management of the company insist on the constant training of employees and the raising of their awareness on the importance of preserving the environment. In 2021, several actions supporting this area were organized, in accordance with Corporate Social Responsibility (CSR) company strategy that supports the SDGs. The compliance with the principles of CSR is a necessity if the company tends to participate in global supply chains. EU and multinational companies usually choose suppliers from the global supplier basis, such as EcoVadis (a *ratings platform to assess corporate social responsibility and sustainable procurement)*. Bosis company has a label of Platinum supplier, which means that is among the top 1% of companies (of a total of over 100,000 companies that have passed the EcoVadis check) in all categories that meet high CSR requirements.

In addition to this, Bosis has been calculating its GHG emissions for several years, and from 2020 they also prepared an annual GHG emissions report according to the international GHG Protocol standard. At the moment, the Bosis GHG emissions report

contains only SCOPE 1 (direct GHG emissions from company-owned and controlled resources, released into the atmosphere as a direct result of a company's activities) and SCOPE 2 (indirect GHG emissions released in the atmosphere from the consumption of purchased electricity, steam, heat, and cooling), but Bosis actively works to include SCOPE 3 (all indirect emissions not included in SCOPE 2, that occur in the value chain of the reporting company, including both upstream and downstream emissions).

All of this is of extreme importance both for local regulations (the law on climate change of the Republic of Serbia was adopted in 2021, but Bosis is awaiting the adoption of by-laws that will more closely define the way of reporting on GHG emissions) and for European regulations. Namely, in the EU, laws on the carbon tax have already been passed, which implies the payment of additional taxes for the import of products in proportion to their carbon footprint (i.e., the amount of GHGs released into the atmosphere in the process of their production and transport). This regulation currently covers the import of heavy industry products, but it is expected that in the near future this tax will be extended to all products imported into the EU. By working on timely data collection and reporting and reducing GHG emissions, Bosis's products will have a smaller carbon footprint and would be competitive on the EU market.

It has to be emphasized that major clients of the Bosis Company belong to the food industry. According to the EC Packaging and Packaging Waste Directive, packaging functionality is particularly important for sensitive applications being in contact with food and beverages. The safety of food products and consumers is the first priority for the packaging supply chain, and it is also what drives the search for the best sustainable solutions (e.g., for the further uptake of recycled content). Finally, producers need to remain free to choose the most appropriate packaging formats and materials for their products and their distribution systems. Because of those recommendations, Bosis deploys packaging solutions together with their clients.

Considering that Bosis has been reducing negative impacts on the environment for years, the introduction of the CE principle is a logical step to achieve the goal of zero levels of GHG emissions. The company strives to operate transparently, publishing the results of their commitment through a sustainability report aligned with the Global Reporting Initiative (GRI) methodology. The implementation of the CE concept is expected to lead in the long-term to positive financial effects, optimization of the production process, increased effectiveness and efficiency, and a positive impact on the local community, employees, and their families, which is always a company's main motive and driving force.

4. Results

In this section, the results of this research are reported. First, in Section 4.1. the framework built to explore the company selected is presented and then, in Section 4.2. the application case results are reported.

4.1. Conceptualization Phase: Literature Review

In the conceptualization phase the contributions selected were categorized into three parts.

The first category refers to the literature that emphasized the research of CE readiness of companies operating in developed countries. In this context, ref. [43] developed the CE readiness self-assessment tool as an important guidance to support the successful transition towards CE of manufacturing companies by identifying the eight key dimensions that that are necessary for manufacturing companies to make the transition to CE: (1) Organization; (2) Strategy and Business Model Innovation; (3) Product and Service Innovation; (4) Manufacturing and Value Chain; (5) Technology and Data; (6) Use, Support, and Maintenance; (7) Takeback and End-of-Life Strategies; and (8) Policy and Market. In addition, ref. [44] created a unified assessment framework to evaluate the circularity readiness of EU economies and emphasized that policies and regulations must support companies to understand that circular products and processes generate added value. At the same time, the latest research of [56] indicated that, even in a developed country (Finland), CE is in a very early phase

among companies, which are mainly interested in maintenance, repair, modernization, reuse (resales), and remanufacture, while material recycling is not a core of their business model.

The second category emphasized different conceptual models and frameworks for the assessment of CE readiness, looking also at the main drivers and barriers of adopting CE business models and with a focus on characteristics that they could have. In that sense, ref. [41] proposed a readiness assessment model for manufacturing companies that frequently fail in understanding how to start a systemic transition, in which fundamental changes are needed in the design of products, production processes, business models, and supply chains. Ref. [51] explored the textile recycling sector and found that the main enhancing factors are relevant regulations at the European level, appropriate technologies and digitization, and increasing social and environmental awareness of consumers and managerial capabilities. Supply chain complexity was emphasized as one of the main inhibiting factors. Ref. [59] found that the majority of the frameworks are not readiness frameworks within a strategic business context but more about a list of CE characteristics as a tool to promote CE activities. Ref. [40] emphasized that there is no comprehensive readiness model for SMEs adopting CE, so their intention was to develop a conceptual model to measure change readiness for SMEs' adopting CEs by incorporating several factors as precursors to readiness, i.e., individual/collective difference, structural, contextual factors, and related barriers. Ref. [58] found that corporate environmental responsibility (CER) positively influences the readiness for change in organizations. Parallelly with the activities on the supply side and aimed at increasing the level of companies' readiness for implementing new business model based on CE, different activities should be realized on the demand side in terms of deploying the environmental consciousness of citizens and consumers through the programs of environmental education and similar activities of public authorities and decision-makers, as was emphasized in the research of [66].

The third category deals with the literature related to CE readiness in developing countries. Ref. [67] identified several opportunities for CE transitions in Columbia and other low- and middle-income economies: greater political coherence; a suitable fiscal framework for sustainable practices; a robust IT infrastructure; and the use of ICT by enterprises to develop CE business models. They also emphasized the necessity of promoting financing schemes and incentives to implement design-led approaches to production in the industrial sector. Innovations, education, and raising awareness would additionally support a mind-set shift. Ref. [68] researched possibilities for a transition to a circular plastic economy (CPE) in Africa and emphasized the importance of a more collaborative, multistakeholder, and multi-sectoral synergy needed to break the linear economy, supported by government's investment in capacity and skills building, education, financial incentives, and taxation to further facilitate CPE.

The main contributions from the analysis of the literature are that the transition to CE requires radical changes in products, processes, and business models and that it has to be regulatory supported by public authorities, as well as through financial schemes and tax incentives. It could be especially important for developing countries and low/middle income economies where awareness of sustainable business and corporate social responsibility are not developed enough.

4.2. The Framework to Measure Companies' CE Readiness in Developing Countries

In this research, the framework developed by the European Environment Agency (2016) was refined as a comprehensive overview of elements and preconditions for measuring the progress of manufacturing companies towards circularity. The monitoring framework covers all of the relevant dimensions of the transition: material inputs, eco-design, production, consumption, and waste recycling. Different policy questions were set, as well as indicators for measuring progress towards CE, and on the basis of the analyzed company's answers and data availability, progress was measured. An additional model for assessing progress towards product circularity was also developed by the EEA [37] and integrated in this research.

The model is composed of two main parts: the first is aimed at measuring and assessing progress towards the circularity of a product and the second part presents different perspectives from the company point of view, evaluating how to shift its business model to a circular one.

In this framework, the main perspectives to assess products' circularity (detailed in Table 1) are:

1. Product properties: technical lifetime of a product; reparability, and recycled content of a product;
2. Business/consumption model: material circularity indicator (MCI), functional lifetime of a product, and proportion of product-service system (PSS);
3. Society: policy framework;
4. Macro-scale product impacts: macro-scale impacts of circular business model and the proportion of key material losses in product cycles;
5. Environmental and economic impacts: life cycle impact analysis, exergy losses, and life cycle costing (LCC).

To realize in an easier way the maturity level based on the answers of the interviewees, researchers also defined normative answers for each question. An example of normative answers for product circularity is reported for question 1.1 ("Which is the duration of a technical lifetime of a product?"):

1. Completely unready: duration of the technical lifetime of a product is strongly shortened;
2. Partly unready: duration of the technical lifetime of a product is shortened;
3. Neither unready, nor ready: duration of the technical lifetime of a product is unchanged;
4. Partly ready: duration of the technical lifetime of a product is slightly extended;
5. Completely ready: duration of the technical lifetime of a product is strongly extended.

Instead, the second part of the framework (detailed in Table 2) deals with assessing business model circularity. Its main categories are material input, eco-design, production, consumption, and waste recycling.

Table 1. Assessing product circularity.

Dimensions	Circularity Assessment	Related Questions	
Product properties	Technical lifetime of a product	1.1	Which is the duration of a *technical* lifetime of a product?
	Reparability	1.2	Is there an ability for reusability, remanufacturing, or recyclability?
	Recycled content	1.3	What is the proportion of recycled material in new products?
Business consumption model	Material circularity indicator (MCI)	2.1	Which methodology integrates product characteristics and circular strategies available in an easy-to-use format?
	Functional lifetime of a product	2.2	What is the functional lifetime of your products?
	Proportion of product-service system in specific market	2.3	What is adoption rate of a product-service system?

Table 1. *Cont.*

Dimensions	Circularity Assessment	Related Questions
Society	Policy framework	3.1 What aspects of product circularity are stimulated or hampered by policy instruments? 3.2 What is the size of the market that is affected by these policy instruments? 3.3 What groups are targeted by the policy instrument? 3.4 Are there instruments that influence the design of products such as taxes on specific products or differentiated VAT rates? 3.5 Are there any policy measures in place favoring local production and local reuse or recycling services to shorten the transport distance between production, consumption, and reuse/recycling? 3.6 Are there policy measures in place engaging the distribution sector in stimulating local reuse and repair? 3.7 Are any policy measures in place favoring the separate collection of waste for reuse and/or recycling? 3.8 Are there any instruments that support remanufacturing? 3.9 Are there any instruments in place for stimulating the market for recyclates? 3.10 Are there any standards on reuse/recycling or reusables/recyclates? 3.11 Are there public procurement schemes designed to incentivize the innovators and early adopters to come up with new products/new business models that are more circular?
Macro-scale product impacts	Macro-scale impact of circular business models	4.1 Is it possible to assess the macro-scale economic and environmental impacts of circular business models?
	Proportion of key material losses in product cycles	4.2 Is it possible to obtain insights on key product flows in terms of opportunities for increasing circularity and decreasing material losses? Is it possible to assess leakage of key materials from a material cycle?
Environmental-economic aspects	Life cycle impacts	5.1 Is the LCA (life cycle assessment) methodology in usage?
	Exergy losses	5.2 Is there monitoring of exergy losses?
	LCC	5.3 Is the life cycle cost (LCC) analysis used?

Furthermore, in the case of the part of the maturity model related to the business model, to quantify and translate the qualitative answer provided by the interviewees in a quantitative rate, researchers defined normative answers. An example of normative answers for product circularity is reported for question 1.1 ("Are primary material inputs decreasing in your company?"):

1. Completely unready: primary material inputs flows are strongly increasing;
2. Partly unready: primary material inputs flows are increasing;
3. Neither unready, nor ready: primary material inputs flows are steady;
4. Partly ready: primary material inputs flows are slightly decreasing (e.g., through the recycling of wastes);
5. Completely ready: primary material inputs flows are strongly decreasing (e.g., through design modifications on the product).

Table 2. Assessing business model circularity readiness.

Categories		Policy Question
Material Input	1.1	Are primary material inputs decreasing in your company?
	1.2	Are material losses decreasing in your company?
	1.3	Is the share of recycled materials in material input increasing in your company ?
	1.4	Are the materials used in your company sustainably sourced?
Eco-Design	2.1	Are your products designed to last longer?
	2.2	Are your products designed for disassembly?
	2.3	Are recycled materials included in product design?
	2.4	Are the materials designed to be recycled, avoiding pollution from recycling loops?
Production	3.1	Does your company use fewer materials in production?
	3.2	Does your company use a lower volume and number of environmentally hazardous substances in production?
	3.3	Does your company generate less waste in production?
	3.4	Are business strategies shifting towards circular concepts such as remanufacture and service-based offers?
Consumption	4.1	Does consumption in Serbia switch patterns to less environmentally intensive types of goods and services?
	4.2	Do consumers in Serbia use products for longer?
	4.3	Does consumption in Serbia generate less waste?
Waste recycling	5.1	Is waste increasingly recycled in your company?
	5.2	How far do materials keep their value in recycling processes, avoiding down-cycling in your company?
	5.3	How far is the Serbian recycling system optimized for environmental and economic sustainability?

4.3. Application Case Results

4.3.1. Product Circularity Readiness Assessment

The assessment of Bosis' readiness in terms of product circularity went through the five dimensions introduced in Table 1 and started with the dimension "product properties", divided into:

1. Technical lifetime of a product: technical lifetime of a cardboard packaging is directly determined by the materials used and can be extended by changing the ways the products packed in cardboard packaging are distributed to customers and used.
2. Ability for reusability, remanufacturing or recyclability of a product: the cardboard packaging is fully recyclable and made from recycled materials. In its production,

high quality materials are used which comply with the standards, and, at the same time, originate from responsible and sustainable sources. All used materials are approved for packaging for the industries that have most demands regarding health and safety, such as food and confectionary industry. Almost 14% of the total portfolio are Forest Stewardship Council (FSC) certified products, having the FSC logo as a guarantee that the packaging was produced using exclusively materials originating from responsible sources. There are 142 new FSC products in their portfolio. The next steps will be aimed at the improvement of collecting, selecting, and recycling of paper and cardboard packaging.

3. Proportion of recycled materials in new products: the proportion of recycled materials in products is about 94 %. The next steps will be aimed at increasing the proportion of recycled materials and materials with a lower share of virgin fibers in paper and cardboard packaging.

Three sub-dimensions have been considered for the dimension of "consumption":

1. Material circularity indicator (MCI): the company uses MCI to detect key problems related to product circularity and the way the business model contributes to actual reuse, recycling, a longer lifespan, and more intensive uses of the packaging. In total, 100% of the paper waste generated in the production process is recycled. The design function is developing packaging, in cooperation with dedicated customers, with more sustainable materials and packaging solutions, more functions, and extended lifespans. In addition, the eco-design of packaging in the product portfolio enables more functions, communicates the values of sustainable consumption, and contains the smallest necessary amount of material. The types of material and cardboard grammage are selected carefully, and the quantity of material input is optimized, while the functionality of products is retained. The weight of packaging was reduced by reducing the thickness or quantity of the materials. The next steps will be aimed at improving the awareness of packaging buyers and designing products with extended lifecycles.
2. Functional lifetime of a product: the functional lifetime of paper and cardboard packaging depends on the lifetime of the materials used in production, which is determined by the suppliers of the materials. The next steps will be aimed at cooperating with the suppliers of the material on improving the functional lifetime of materials and packaging.
3. Proportion of PSS in a specific market: the proportion of PSS in a specific market is still not applied in the analyzed company, but there is intention to develop PSS in the future.

The "Policy framework" was assessed in terms of the impact of society through the following sub-dimensions:

1. Aspects of product circularity stimulated or hampered by policy instruments: there are only requirements for using Standards 13430 and 13428;
2. Size of the market that is affected by policy instruments: there is no official data about the size of the market affected by policy instruments;
3. Groups targeted by policy instruments: there is no official data about the number and size of the groups targeted by policy instruments;
4. Instruments that influence the design of products (e.g., taxes on specific products or differentiated VAT rates): the company is not aware of the existence of instruments that influence the design of a product;
5. Policy measures in place favoring local production and local reuse or recycling services to shorten the transport distance between production, consumption, and reuse/recycling: no existing measures. Waste cardboard and paper can be recycled only in a few plants in the country, so transportation depends on the distance of the plants;

6. Policy measures in place engaging the distribution sector in stimulating local reuse and repair: such policy measures do not exist;
7. Policy measures in place favoring the separate collection of waste for reuse and/or recycling: there are a number of policies and procedures in place (e.g., the National Plan for the reduction of packaging waste, the law on packaging and packaging waste);
8. Instruments that support remanufacturing: they are defined by procedures (e.g., regulation on the list of waste generation prevention measures);
9. Instruments in place for stimulating the market for recyclates: they are defined by procedures;
10. Standards on reuse/recycling or reusables/recyclates: there are only internal procedures for this area;
11. Public procurement schemes designed to incentivize the innovators and early adopters to come up with new products/new business models that are more circular: there are no such public procurement schemes.

The "Macro-scale product impact" has been assessed through the following sub-dimensions:

1. Macro-scale economic and environmental impact of the circular business model: it is possible to assess the macro-scale economic and environmental impacts of circular business models by taking into account all of the connections between the material inputs, outputs, and processes of the business model, the environment, and society. Products are marked in accordance with international standards so that all users, from the manufacturer to the end customer, can easily manage packaging and waste. All products are labelled with PAP 20 (paper recycling code: Cardboard) and PAP 21 (paper recycling code: Mixed Paper) depending on the type of packaging to manage the waste in the chain. The company monitors the suppliers in the chain, as well as the operators and buyers of waste. The analyzed company consumes energy and water responsibly. Energy consumption was decreased by applying more efficient equipment, such as automated press control, intelligent system of heating and air conditioning, sensors for turning on/off the lighting, and a control system with frequency regulators for the main engines great forces. The system for the expulsion waste of paper and cardboard was replaced with a new system that consumes four times less energy. The electricity consumption per processed ton of raw material also decreased. The means of internal transport which used gas and diesel engines was replaced with vehicles powered by electricity. New technologies that reduce GHG emissions were implemented. LPG has been replaced with CNG in the production of steam. Coal heating was replaced with pellet heating which reduced the GHG emissions. Water consumption per ton of raw material decreased (in the last 3 years) to about 0.586 m^3/t. Water dispersion materials which do not pollute the water were used. Chemistry for developing an offset plate with a minimum using of water was used. Equipment for the chemical preparation of water which reduces the water consumption were installed, as well as efficient equipment with a CNG gas burner for the production of water steam. The next steps will be aimed at creating a framework which would help partner companies easily assess the macro-scale economic and environmental impacts of their business models;
2. Key product flows and proportion of key material losses in product cycles: methodologies are available, but data availability is limited considering the industry and material inputs, and the results often do not communicate product-level information. Material losses have been significantly decreased during the last few years. The next steps will be aimed at improving the methodology for obtaining insights in the key product flows to decrease the key material losses and leakage.

"Environmental economic aspects" have been assessed through the three following sub-dimensions:

1. Application of the Life Cycle Assessment (LCA) methodology: the company applies the LCA methodology within the internal assessment system to better track the impact

of production to GHG emissions, water, air, and soil. The next steps will be aimed at implementing LCA analysis into the design phase of all new processes and products;
2. Exergy losses: exergy losses are not monitored;
3. Life cycle cost (LCC) analysis: it is applied by evaluating investments, especially production machine purchases.

In addition, for each answer, a value from the five-point Likert scale was assigned for the sustainability manager. Finally, by computing the average value of each of the five dimensions analyzed, a total score expressing the company's readiness was obtained (Table 3). The results are graphically presented in the radar chart shown in Figure 2.

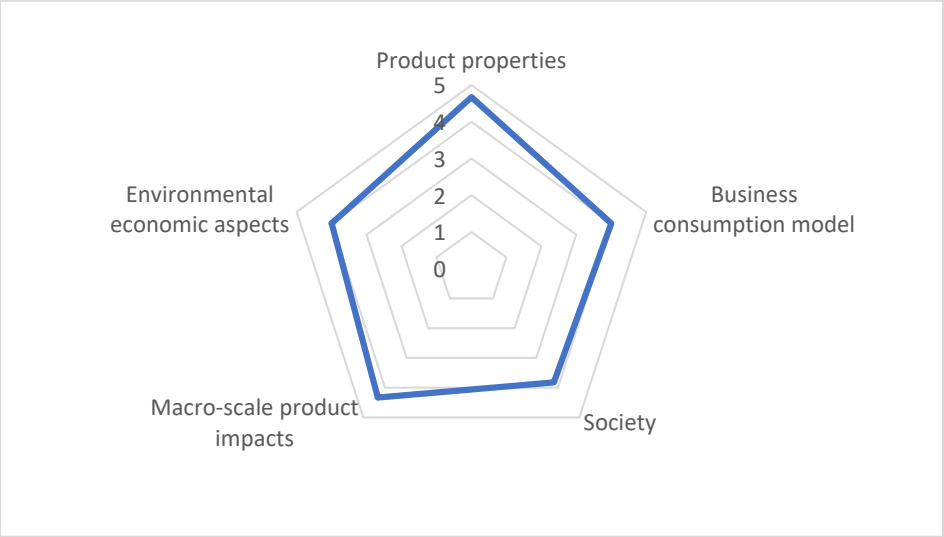

Figure 2. Radar chart for assessment of product's circularity.

Figure 2 indicates that the highest average value was obtained for the circularity assessment regarding the *Product properties* (4.67) dimension as a result of the continuous extending of a technical lifetime of a product, ability for reusability, remanufacturing or recyclability of a product, as well as increasing the share of recycled materials in new products. Regarding the *Macro-scale product impacts dimension,* the obtained average value was 4.33 as result of the continuous effort of the analyzed company to assess the economic and environmental impact of its business model, to obtain insights on key product flows as opportunities for increasing circularity and decreasing material losses, and to assess the leakage of key materials from a material cycle. The company applies LCC analysis when evaluating investments, LCA in internal assessment systems to better track the impact linked to emissions to water, air, and soil during the production, but does not monitor exergy losses, which have reflected the average value of four for the *Environmental economic aspects* dimension. The same average value was obtained for the *Business consumption model* dimension regarding the actual business model, which contributes to the reuse, recycling, a longer lifespan, and more intensive use of the products. There are also internal procedures on reuse/recycling or reusables/recyclates, but public procurement schemes are not designed to incentivize the innovators and early adopters to come up with new products/new business models that are more circular. The lowest average value was obtained for the *Society* dimension because of the lack of financial incentives and stimulative instruments and policy measures that would favor local production and local reuse or recycling services, would promote the eco-design of products, and would promote the separate collection of waste for reuse and/or recycling, stimulating the market for recyclates and promoting remanufacturing.

Table 3. Average values for each dimension of product circularity (for the respondent: sustainability manager).

Dimension	Sub-Dimension	Score
1. Product properties	1.1. Increase in technical lifetime of a product	4
	1.2. Ability for reusability, remanufacturing, or recyclability	5
	1.3. Increase in proportion of recycled material in new products	5
	Average value	**4.67**
2. Business consumption model	2.1. Contribution of actual business model to reuse, recycling, a longer lifespan	5
	2.2. Increase in functional lifetime of products	4
	2.3. Application of PSS in specific market	3
	Average value	**4.00**
3. Society	3.1. Stimulation of product circularity by policy instruments	4
	3.2. Increase in size of market affected by policy instruments	5
	3.3. Existence of groups targeted by the policy instrument	5
	3.4. Existence of instruments that influence the design of products	3
	3.5. Existence of policy measures in place favoring local production and local reuse or recycling services	2
	3.6. Existence of policy measures in place engaging the distribution sector in stimulating local reuse and repair	2
	3.7. Existence of policy measures in place favoring the separate collection of waste for reuse and/or recycling	5
	3.8. Existence of instruments that support remanufacturing	5
	3.9. Existence of instruments in place for stimulating the market for recyclates	4
	3.10. Existence of standards on reuse/recycling or reusables/recyclates	5
	3.11. Existence of public procurement schemes designed to incentivize the innovators and early adopters	2
	Average value	**3.82**
4. Macro-scale product impacts	4.1. Possibility to assess the macro-scale economic and environmental impacts of circular business models	4
	4.2. Insights on key product flows	5
	4.3. Possibility of assessment of leakage of key materials from a material cycle	4
	Average value	**4.33**
5. Environmental economic aspects	5.1. Implemention of LCA methodology	5
	5.2. Monitoring of exergy losses	2
	5.3. Application of LCC analysis by investments' evaluation	5
	Average value	**4.00**

4.3.2. Business Model Circularity

The assessment of a company's readiness to transition its business model towards a circular one has been tested through the five dimensions introduced in Table 2: material input; eco-design; production; consumption; waste recycling. For each of them, a set of sub-dimensions was investigated, detecting possible indicators and verifying the related data availability for their calculation.

In the "material input" dimension, four main sub-dimensions were explored:

1.1. Primary material inputs: the production volume and consumption of material inputs (cardboard, packaging paper) increased but at the same time the increase in the production efficiency and reduction in waste contributed to reducing the amount of material wasted. In cooperation with customers, packaging solutions were developed with a reduced quantity of material inputs, without reducing the functionality of the product (types of material and cardboard grammage were carefully selected). A possible indicator is the domestic material consumption (DMC) for which calculation data are already available.

1.2. Material losses: material losses (of paper, cardboard, energy, and water) significantly decreased during the previous years. A possible indicator is the proportion of material losses in key material cycles. For its calculation, data are not fully available to create the indicator.

1.3. Share of recycled materials in material input: the use of recycled materials increased. A possible indicator is the share of secondary raw materials in material consumption (that amounts to 94%), for which calculation data are already available.

1.4. Materials used sustainably sourced: high-quality materials, which comply with the standards and at the same time originate from responsible and sustainable sources, were chosen by the company. All used materials were approved for packaging for the industries that have most demands regarding health and safety (such as food and confectionary industry). This is confirmed by certificates on the health control of packaging, received from the suppliers of the material. The 13.91% FSC of the products' portfolio was certified with the FSC logo as a guarantee that the packaging was produced using exclusively materials originating from responsible sources (responsibly managed forests), from a transition from cellulosic to recycled materials, and from the use of recycled materials containing a lower % of virgin fibers directly results with less deforestation. A possible indicator is the share of sustainably sourced certified materials in material use (by key materials), for which calculation data are not fully available.

For the "eco-design" dimension, four topics were analyzed:

2.1. Products designed to last longer: the design function was developing products, in cooperation with its buyers, considering the practical and specific needs of the given product that was packed in packaging. The lifespan of certain types of packaging was significantly extended, while in some cases it must be shorter (as much as necessary until it fulfills its primary purpose). The eco-design of packaging enabled an extended lifespan, adds value to the product, communicates the values of sustainable consumption, and contained the smallest necessary amount of material. In this way, packaging is suitable for recycling and has more functions and an extended lifespan. One example is collective display packaging, which, in addition to transport (protects products during storage and transport), also has a marketing function (they have an attractive design and print and are suitable for displaying products on market shelves). A possible indicator is durability or lifetime compared with an industry average for a similar product; data are available to create this indicator.

2.2. Products designed for disassembly: the purpose of the packaging produced was one-time use, after which the packaging is recycled and can be used again in the production process. The packaging design enabled easy folding/unfolding and made packaging functional for easy disposal after usage. A possible indicator is time and the number of necessary tools for disassembly; no data are currently available to create this indicator.

2.3. Recycled materials included in product design: recycled materials were used in production. The proportion of recycled materials in products (January–June 2022) was 94%; 2.55% of the materials originated from natural fibers; and 70.36% were FSC-certified materials. A possible indicator is the proportion of recycled material in new products; data are available to create this indicator.

2.4. Materials designed to be recycled, avoiding pollution from recycling loops: the products were fully recyclable. The eco-design concept was developed keeping in mind the B2B2C concept, based on collecting information from the end consumers (i.e., the consumers of the product) and taking into account their requests about packaging. In the production of packaging, the minimum necessary quantity of material was used, with the highest

proportion of recycled material and ecological materials, paints, and varnishes. A possible indicator is the share of materials where safe recycling options exist; data are available to create this indicator.

Regarding the "Production" dimension, four main sub-dimensions were investigated:

3.1. Use of fewer materials in production: the philosophy of smart design implies the use of a minimum quantity of material for the packaging of a specific product. By the production of sample products for customers, an optimal quantity of material inputs is applied. Sustainable consumption of packaging was promoted and a reduction in the consumption of materials was applied through customer advising. Using box compression, optimal carrying capacity of boxes and optimal use of materials was determined. A possible indicator is the material used for production compared to GDP (potentially by sector); data are available to create this indicator.

3.2. Use of a lower volume and number of environmentally hazardous substances in production: the company uses a lower volume and number of environmentally hazardous substances in production. A possible indicator is the input of substances that are classified as hazardous; data are available to create the indicator.

3.3. Generation of less waste in production: a downward trend in waste generation was marked. Automatic selection and waste collection in production were implemented and all generated waste paper was recycled. Possible indicator are waste generation (production activities) and the generation of hazardous waste in production processes; data are available to create this indicator.

3.4. Business strategies shifting towards circular concepts (such as remanufacture and service-based offers): the company strives to achieve circularity in all production and business processes and to optimize the entire production process. Currently, service-based offers do not exist. A possible indicator is the involvement of companies in circular company networks; limited data are available to create this indicator.

About the "Consumption" dimension, the following sub-dimensions were considered:

4.1. Consumption in the analyzed developing country switch patterns to less environmentally intensive types of goods and services: the trend of environmentally positive business processes, materials, and practices has taken off in Serbia as well and the number of companies that are guided by these principles in business is increasing. The possible indicators are the environmental footprint of consumption (including materials) in Serbia and the material footprint per euro spent; limited data are available to create this indicator.

4.2. Consumers in the analyzed developing country use products for longer: the purchasing power of inhabitants of Serbia is lower compared to the west, so people tend to use the products with longer lifespans. As the economic situation improves, the consumerism trend will be adopted by more people, with negative influences on the environment. The possible indicators are the actual average lifetime of the selected products and the market share of preparing for reuse and repair services related to the sales of new products; limited data are available to create this indicator.

4.3. Consumption in the analyzed developing country generates less waste: municipal waste in Serbia is not managed. Poor waste management has been identified as one of the most important barriers for successful waste management in Serbia. A possible indicator is waste generation; data are available to create this indicator.

Concerning "waste recycling", three sub-dimensions were investigated:

5.1. Increasingly recycled waste: a lot of attention has been paid to waste management. In total, 100% of the wasted cardboard and paper generated in production have been recycled. Products are marked in accordance with international standards so that all users, from the manufacturer to the end customer, can easily manage packaging and waste. All products are labelled with PAP 20 (paper recycling code: Cardboard) and PAP 21 (paper recycling code: Mixed Paper) depending on the type of packaging to manage the waste in the chain. The company monitors suppliers in the chain, as well as operators and buyers of waste. Recently, new investments in equipment have been made (system for the automatic removal of paper and cardboard waste from production and a baling press with a larger

capacity which will be able to meet the increase in production capacity in the future). In terms of waste management, all employees and other stakeholders are engaged and trained on how to manage waste. Trainings and "awareness" programs are organized on a regular basis. A possible indicator is the recycling rate for different types of wastes/materials; data are available to create this indicator.

5.2. Materials keeping their value in recycling processes, avoiding down-cycling: There is some difference in using recycled and virgin materials, but it is not big; using virgin materials is better in some processes while others handle the recycled materials in a better way. Packaging is produced according to the customer specification. The possible indicators are the recycled material quality compared with the virgin material quality and the turnover of key recyclables; limited data are available to create this indicator.

5.3. Developing country recycling system optimized for environmental and economic sustainability: this is continuously being improved to include more diverse and complex material recycling processes, for which there is great interest from both private and government stakeholders. The possible indicators are the environmental effects and cost/revenues of municipal waste management in Serbia; limited data are available to create this indicator.

In addition, for each answer provided by the sustainability manager related to the second part of the framework, a score was assigned on the five-point Likert scale. Finally, computing the average value of each of the five dimensions analyzed, a total score expressing the company readiness was obtained (Table 4). The results are graphically presented in the radar chart shown in Figure 3.

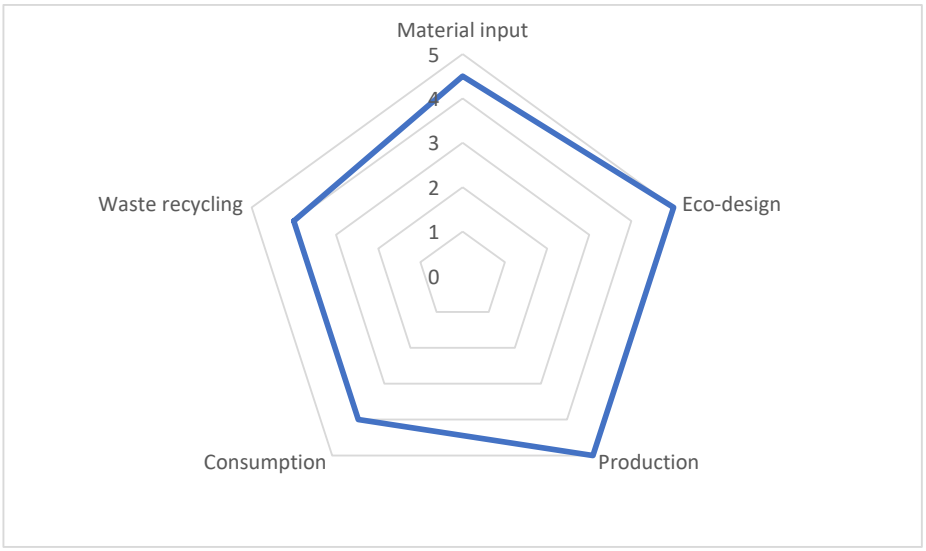

Figure 3. Radar chart for assessment of Business model circularity.

The graph presents that the *Eco-design* and *Product* dimensions have the highest average values, which indicates that the analyzed company designs its product to last longer, to be made from recycled materials, to be eligible for disassembly, to use a lower volume and number of environmentally hazardous substances, and to generate less waste in production. The average value of 4.5 for the *Material input* dimension indicates that there is a space for improvement in terms of further decrease in the material input, although the company strives to increase the efficiency of the used materials. The *Consumption* dimension with an average value of four indicates that there is a possibility for improvement from the macro point of view regarding using products with longer lifespans and generating less waste. The *Waste recycling* dimension with average value of four indicates that, although waste has increasingly been recycled in the analyzed company, there are still a lot of possibilities for the optimization of the Serbian recycling system to reach environmental and economic sustainability.

Table 4. Average values for each dimension of business model circularity.

Dimension	Sub-Dimensions	Score
1. Material input	1.1. Primary material inputs	3
	1.2. Material losses	5
	1.3. Share of recycled materials in material input	5
	1.4. Materials used sustainably sourced	5
	Average value	**4.33**
2. Eco-Design	2.1 Duration of products	5
	2.2 Possibility for dissasembly	5
	2.3. Inclusion of recycled materials	5
	2.4. Possibility for recycling and avoiding pollution from recycling loops	5
	Average value	**5.00**
3. Production	3.1. Decreasing quantity of materials used in production	5
	3.2. Decreasing volume and number of environmentally hazardous substances in production	5
	3.3. Decreasing volume of waste in production	5
	3.4. Business strategies towards circular concepts	5
	Average value	**5.00**
4. Consumption	4.1. Switch of consumption trends in analyzed country to less environmentally intensive types of goods and services	4
	4.2. Extended usage of products in analyzed country	4
	4.3. Trend of generating less waste in analyzed country	4
	Average value	**4.00**
5. Waste Recycling	5.1. Increase in waste recycling in analyzed company	5
	5.2. Retaining value of materials in recycling processes, avoiding down-cycling in analyzed company	4
	5.3. Optimization of recycling system of analyzed (developing) country for environmental and economic sustainability	3
	Average value	**4.00**

5. Discussion

In this section, the results obtained with this research are discussed, giving evidence to the next steps set by the company during the product circularity readiness assessment and also providing a set of indexes that could help the transition of the company's business model towards a full embracement of the circularity paradigm.

This research is triggered by the need to contribute to the CE paradigm that is in a very early phase among manufacturing companies [56]. Indeed, researchers highlighted the gap between the CE theory and real manufacturing practices. The results of this research are also in line with the research of Ref. [69] who found that in developing countries the background for CE development is quite different from developed countries, where there is an established waste management structure and a robust environmental policy.

5.1. Product Circularity: Next Steps for the Transition

The next steps related to the product circularity assessment can be detected for each sub-dimension analyzed. Regarding the *Product properties* dimension, possible next steps

will be aimed at improving the collection, selection, and recycling of paper and cardboard packaging, as well as increasing the proportion of recycled materials and materials with a lower share of virgin fibers in paper and cardboard packaging. There is also an intention to work with customers to change the ways that the products packed in paper and cardboard packaging are sold and used. Therefore, user involvement will be a key factor in the innovation of products from a circular perspective [70,71].

Regarding *Business model consumption*, next steps will be aimed at improving the awareness of packaging buyers and designing products with extended lifecycles, followed by the extension of the functional lifetime of materials and packaging. Having in mind that PSS in specific market is still not applied, there is an intention to develop PSS [72] in the future.

Next steps regarding the dimension *Society* will be aimed at triggering bottom-up initiated discussions with public authorities by providing them with the feedback needed to develop and adapt regulatory frameworks and incentive schemes [73] to generate and boost CE in a developing country [74].

In terms of the *Macro-scale product impact*, next steps will be aimed at creating a framework which would help partner companies to easily assess the macro-scale economic and environmental impacts of their business models [75]. Additional important next steps will be aimed at improving the methodology to obtain insights in the key product flows and to decrease key material losses and leakage.

In terms of *Environmental economic aspects*, next steps will be aimed at implementing LCA analysis in the design phase of all new processes and products [33]. Exergetic efficiency gives a good indication of how efficiently materials or energy sources are used [76]. Having in mind that exergy losses are still not monitored, one of next steps will be aimed at their monitoring.

5.2. Business Model Circularity Readiness: Indexes to Lead the Transition

An assessment of the company's readiness for transitioning towards circular business models was tested through different perspectives.

Concerning *Material input*, the key performance indicator (KPI) of *Domestic material consumption (DMC)* was applied to test whether the primary material inputs decrease. Instead, to assess whether the material losses decrease in the company, *Proportion of material losses* can be used as a KPI. In addition, the *Share of secondary raw materials in material consumption* indicates proportion of recycled materials in the total material input. An important KPI to explain the overall behavior for the *Material input* sub-dimension is the *Share of sustainable-certified materials in total material use* (for key materials).

Dealing with the Eco-design dimension, one KPI is the durability or lifetime compared with an industry average for a similar product. To assess the possibility of disassembly, time and the number of necessary tools for disassembly were detected. Instead, the proportion of recycled material in new products was used to assess the inclusion of recycled materials in the product design. In a prolonged product vision, the lifecycle share of materials where safe recycling options exists is used as the KPI and indicates whether the materials are designed to be recycled, avoiding pollution from recycling loops.

Regarding *Production, the material used for production compared to GDP* (potentially by sector) could be used as a KPI to test trends for using fewer materials in production. The companies should also assess the *Input of substances that are classified as hazardous*. Instead, to assess the trend of generating less waste in production, the KPI of the *Generation of hazardous waste in production processes* can be used. Finally, with a meso perspective on production processes, the *Involvement of companies in circular company networks* should indicate whether the business strategy of a company supports shifting towards circular concepts.

Concerning *Consumption*, possible KPIs assessing different aspects of user behaviors and their impacts linked to the properties of the product provided by the company are the environmental footprint of consumption (including materials) in a developing country, the material footprint per euro spent, the actual average lifetime of selected products and the market share of preparing for reuse and repair services related to the sales of new products, and waste generation by consumers in a developing country.

From the perspective of *Waste recycling*, different KPIs have been detected to measure the amount of waste recycled in a company and the retained value of recycled materials or the optimization of recycling systems including: *Recycling rates for different types of wastes/materials*, *Recycled material quality compared with virgin material quality*, and *Turnover of key recyclables*. To assess whether the recycling systems of a (developing) country are optimized for environmental and economic sustainability, possible KPIs are *Environmental effects and cost/revenues of municipal waste management*.

5.3. Contributions to Knowledge and to Practice, and Managerial and Policy Implications

This paper impacts and contributes to both theory and practice, while also providing useful hints from a managerial and policy perspective.

From the perspective of contributions to knowledge, a framework for assessing company's readiness tailored to companies operating in developing countries was developed. This framework investigates both the product and the business model aspects, while also defining, respectively, future actions and KPIs to lead the company towards a full embracement of the CE paradigm.

This research also contributes to practice. Indeed, the framework constitutes a means to assess the level of readiness of companies willing to embrace the CE paradigm in developing countries, while also giving them the opportunity to split the assessment of the circularity level of their products from the business model perspective. The framework also supports companies to widen their view related to the CE paradigm, looking at different related dimensions (both internal and external to the company boundaries). In addition, the application of the framework proposed could be a useful tool to lead the company towards a circular-driven roadmap and to assess their progress along the time.

Finally, both company managers and decision-makers can exploit the results obtained from this research. Managers can raise their awareness about the main topics related to the CE paradigm and can use it as a support for decision-making in that domain. On the other side, public authorities and policy-makers can obtain fact-based information that could help them to facilitate CE adoption in developing countries.

6. Conclusions

This research developed and proposed a framework tailored for companies operating in developing countries to determine their CE readiness level. In detail, the model investigates the two main perspectives (product and business model) that these companies should consider assessing the readiness of their operations under a CE lens. Through an interactive research method, inspired by DRM [36], the framework, grounded on the EEA's template [8,37], has been conceived and refined. Then, the framework was validated through an application case with a company operating in the packaging industry in a non-EU developing country. The framework turned out to be an easy to use artifact constituted of two main parts, each one split in a set of categories to be investigated and then also detailed in a series of sub-dimensions. For each sub-dimension, related questions to be provided to the company employees were defined, flanked by normative answers useful to help the translation of the open answer received by the interviewees in a quantified value assignable to one of the five specific levels of maturity defined. Finally, to help the companies adopting the framework in their organizations to move towards a higher level of circularity readiness, the framework also assisted interviewees to both explore the future steps to be planned related to the product dimension and define a set of KPIs to monitor and lead the improvement under a circular perspective for their business model.

The main findings of the application case unveiled that the analyzed company had already started a path towards circularity in its business, using recycled materials; designing sustainable products with the buyers of packaging; reducing waste of energy, water, and GHG emissions; and increasing awareness of its employees and partners regarding sustainability. The framework also helped to understand that the circularity concept applied to the business of the analyzed company is part of its strategic business orientation,

and the framework proposed represents a tool to support the improvement of long-term performances.

The application of the framework to the company analyzed also revealed that there is room for improvement in developing countries to foster CE adoption, especially in relation to the policy context. Indeed, policy incentives and instruments of public authorities could considerably support the circular transition process in companies [6], as well as stimulate them, their customers, and the entire community towards a more responsible business [77]. In particular, a consideration specific for Serbia can be performed due to the fact that EC is promoting CE also in the Western Balkans countries [78].

The framework proposed and the related application case conducted in this research (with a Serbian manufacturing company) belong to the research stream of implementing CE in companies' operations. The results indicated that the companies were not in a position to choose whether to behave responsibly to the environment and society. It becomes their legal duty, but it also constitutes an instrument to attract investors, to build good market reputation, to gain new customers and provide them added-value, and to improve their long-term performances.

Notwithstanding the results obtained, this research was not free from limitations. Indeed, the research results were applied only to one company, although this company is leader in the paper packaging industry of Serbia. The case selection could also be seen as one of the limitation factors of this research, even if the sample chosen was purposive, allowing an idiographic (intensive) study of an individual case [79]. Finally, during the application case, only the sustainability manager and his assistant were involved, who were called to provide their subjective perspectives.

All of these limitations open the way to further research. The framework proposed in this article may be seen as the basis for further research in the manufacturing industry of developing countries. Considering the packaging industry, this framework can also be extended to plastic packaging producers, having in mind the necessity of supporting CE adoption in the packaging industry. The application of the framework should also be extended to different companies belonging to developing countries and operating in other industries. Finally, a generic model able to systematically assess organizations' circularity readiness and maturity level placed in both developed and developing countries is still missing in the literature.

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