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A Circular Economy toolkit as an alternative to improve the application of PSS methodologies

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Abstract

Circular Economy (CE) is an alternative to achieve more sustainability and to improve the current economic system through the transformation of the linear and semi-circular flows to circulate ones, keeping products at a higher level of utility and for a longer period of time. Ellen McArthur Foundation (EMF) and IDEO developed a Circular Design Guide (CE toolkit) intended to support companies to apply the circular principles on their own organizations. In this context, some authors noted that the development of a product-service system (PSS) initiative can help in the transition to a CE. The aim of this paper is to evaluate the objectives of the CE Toolkit joint with a PSS methodology already existent in literature. A matrix was applied to analyse the CE toolkit versus the PSS methodology, and a Likert scale was applied to characterize the relation between each stage of the methodology and each objective of the toolkit. The most important findings are related to the absence of CE concepts and its connection to PSS in previously existent methodology, which lacks methods to support the application of it, and lacks the incentive to use recovery techniques as recycling, remanufacturing and reuse of parts on PSS. At the same time, the toolkit lacks some practical aspects of the transition to PSS, such as identifying the competitors and the definition of a very detailed list of equipment and infrastructure required for the business.

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1. Introduction

The linear and semi-circular economic models based on “take, make, dispose” are unsustainable due to the consumption of high quantity of limited natural resources. In this sense, the Circular Economy (CE) is an alternative to achieve sustainability and to improve the current economic system by the transformation of the linear and semi-circular flows to circulate ones. According to Ellen McArthur Foundation (EMF) [1], CE aims to keep products with their components and materials at the highest level of utility and for a longer period.

As outlined by Ellen McArthur Foundation (EMF) [2], the CE can be represented by three main principles in accordance with biological and technical cycles. The principles are:

- Preserve and increase natural capital with the preservation of the finite stocks of non-renewable resources flows, and balance the renewable resource flows
- Optimize resources based on the circulation of products, components and materials. Regarding the technical cycle, alternatives to achieve this principle are: recycle, remanufacturing, reuse and to implement product-service systems (PSS). In relation to the biological cycle, one option is to adopt biogas to generate energy, for example

- Foster the system effectiveness and reduce damage to human issues as related to food, health, education, mobility and shelter and externalities, such as land use, air, water and noise pollution, liberation of toxic substances and climate change.

Product-service system (PSS) is one of the strategies that can be implemented by companies in order to support the transition of the linear economic model to CE. According to Tukker [3], PSS is considered as the most effective instrument for moving society towards CE ensuring the resources-efficiency. Mentink [4] also outlines that companies should turn towards PSS for developing a more circular model. PSS is defined as “a mix of tangible products and intangible service designed and combined so that jointly are capable of fulfilling final customer needs” [5,6]. Kimita;Shimomura [7] also cited that PSS is a specific type of value proposition in which the products and services are delivered jointly. Additionally, these authors stated that in the delivery process are included the phase of products and services use and other customer activities. Consequently, more resources are required and different types of actors are involved. Some authors add that PSS is a strategy that add value to customers, reduces the use of material and energy and leads to lower environmental impacts as compared to an existing traditional business model [8,9,10]. PSS can minimize the environmental impacts of consumption by closing material cycles, reducing the consumption through alternative scenarios of product use, increasing the efficiency and resource productivity and dematerialization of PSSs, besides providing solutions to improve the functional efficiency of each element [11].

However, there are different barriers to develop and implement PSS initiatives [5,9,12]. They are related to companies’ organizations (corporate barriers), habits (cultural barriers) and regulative frameworks (regulatory barriers). Mittermeyer et al. [13] argue that there are three major aspects that companies need to deal with when developing a PSS. The first aspect is the research and development (R&D), which is fundamental to obtain resources and technical knowledge. Additionally, it is essential to integrate the whole cycle of the product. The second one is the relationship between customers and the company, which is key to redesigning the process. The last aspect is the importance of human capital gains when the products are offered integrated with services.

Previous researches [12-15] present PSS methodologies to help companies for developing and implementing a PSS. However, it is not clear if those methodologies incorporate the CE concepts and their principles.

In one of its initiatives, EMF developed a partnership with IDEO, a global design company, in order to create a Circular Design Guide (CE toolkit) in order to help companies in the transition towards CE model for developing products and services in circular flows. By doing so, companies could explore different ways to create sustainable, resilient and long-lasting values based on CE [16]. In this sense, the CE toolkit is composing by four main phases: understand, define, make and release. Each phase has six methods with specific steps and information to guide the implementation of CE. For instance, the “understand” phase encompasses information related to the understanding of circular flows, reflection on how the companies can apply the servitization, etc. The “make” phase

presents information concerning a circular brainstorming, smart material selection and rapid prototyping. In some cases, the methods are related with each other. For instance, the method “understand circular flows” is related to the methods “find circular opportunities”, “circular business model” and “product journey mapping” [17].

In this context, the main goal of this research is to evaluate the objectives of the CE toolkit developed by EMF and IDEO joint with a PSS implementation methodology found in the literature.

The paper is structured as follows. Section 2 presents the research methodology. The third section presents the PSS methodology. Section 4 discusses the outcomes of this research. Finally, section 5 presents concluding remarks.

2. Research Methodology

In order for the main goal of this article to be achieved, a PSS implementation methodology was selected from previous literature. The work of Annarelli et al. [18] guided this selection, as it is the most recent literature review on PSS. Among the PSS methodologies found in [18], the methodology of Morelli [19] had a higher frequency of application in real cases: one in health care sector [13] and another one in a telecentre for nomadic workers and telecommuters [16]. In addition, this methodology is presented in sufficient details for this analysis [13,19].

Then, content analysis was applied in each method of the toolkit, resulting in summarized objectives for each stage (Objective 1, Objective 2...). The next step was analyzing the relationship between the toolkit and the methodology’s content. For that reason, an analysis matrix was created. The toolkit objectives were distributed in rows, and the steps of the methodology were allocated in the columns. During the analysis, a Likert scale was used for representing how deeply the toolkit’s objectives were covered in each step of the methodology (Table 1), as follows:

- 0 - not covered
- 1 - fairly (poorly) covered
- 3 - moderate covered
- 9 - deeply covered

Table 1. An example of the analysis matrix.

Toolkit phase	Summarized objectives	Meth. Step 1	Meth. Step 2	...	Meth. Step <i>n</i>
Phase 1	Objective 1	0	1	...	0
	Objective 2	3	9	...	1

Finally, these results are commented for each phase of the toolkit, and final considerations are presented.

3. PSS Methodology

The methodology of Morelli [19] comprises seven steps, which are presented below. Each step is represented by the letter “S” associated with a sequential number which reflects the sequence of them, followed by a brief description.

- Value proposition [S1] - consists of the definition of which needs the PSS intends to fulfil.
- Market analysis [S2] - consists of the identification of potential users and existing competitors.
- Product/service definition [S3] - consists of the definition of the solution and the PSS components.
- Use-case analysis [S4] - consists of the analysis of different conditions of use of the solution, aiming to obtain a set of requirements for the PSS.
- Tentative architecture [S5] - consists of a prototype service, defined on the basis of previous phases.
- Test [S6] - consists of the test of the tentative architecture, in order to obtain feedback from users.
- Final definition [S7] - consists of the improvement of the tentative architecture and the definition of the final architecture.

The main goal of this methodology is to support designers during the development of PSS initiatives. However, how much does it contribute to the achievement of the shift to a circular economy? The following section presents the analysis between the EMF and IDEO’s toolkit and the PSS methodology.

4. Results and Discussion

The CE toolkit developed by EMF and IDEO helps designing the pathway to a more circular economy considering many aspects of the global economic system. The toolkit consists in four phases in order to guide companies to understand, define, make and release CE initiatives. Each phase of the toolkit comprises six methods which guide the exploration of opportunities and take on projects. The methods introduce users to CE concepts as well as design techniques in order to support complex circular challenges.

In accordance with the toolkit phase, one or more methods are associated with objectives, which describe the purpose of activities that helps companies understand, define, make and release circular initiatives. Based on the method’s description, the objectives outlined for them were summarized. The methods included in the toolkit and its objectives are presented in Table 2, in the second and third columns, respectively. The objectives are being referenced by letter “O” followed by a sequential number. For instance, the first and second methods (understand circular flows and regenerative thinking, respectively) of the phase “understand” have the objective of introduce the key concepts of CE to people involved in the initiative of shift to CE.

Table 2. Summarized objectives of CE toolkit phases

Toolkit Phase	Methods	Summarized Objectives
Understand	Understand circular flows	O1. Introduction of key concepts of CE to people involved in the initiative
	Regenerative thinking	
	Service flip	O2. Reflection on how company can get more circularity in its value proposals
	Insides out	
	Inspiration: digital system	
Learn from nature		

Define	Define your challenge	O3. Reflection about company challenges and opportunities to get the circular economy	
	Find Circular opportunities		
	Building teams	O4. Identification of people to be involved in CE. Who can help or need to be engaged?	
	Circular Buy In		
	Circular Business Models	O5. Think about the circularity on business and how it should affect the customers using the brand	
Create Brand Promise			
Make	User- centered research	O6. Identification and learning on users across whole system	
	Circular Brainstorming	O7. Learning how to brainstorm ideas around the principles of circularity	
	Embed Feedback Mechanisms	O8. Learning with embed feedback mechanisms to recompile comments before release the product or service	
	Smart material Choices	O9. Material, business strategy and prototypes is important to development product and services with focus in CE	
	Concept Selection		
	Rapid Prototyping		
	Release	Product Journey Mapping	O10. Identification of both technical and biological cycles for the new value proposal
		Imagine New Partnerships	O11. Planning and executing partnerships
		Launch to learn	O12. Planning the pilot launch
			O13. Defining learning objectives for the pilot launching
Continuous Learning Loops		O14. Using all the received feedback for analysing planned versus reality, generating an action plan	
		Align your Organization	O15. Using design thinking approach for planning a new value proposal
O16. Getting employees involved in the new value proposal definition			
Create Your Narrative	O17. Communication among stakeholders the trajectory of the company towards circularity		

In order to evaluate whether the objectives explored in the CE toolkit are being covered in the PSS methodology [19], a matrix was elaborated using the Likert scale (Table 3).

Table 3. Matrix of CE toolkit objectives contemplated in the PSS methodology [19]

Toolkit phase	Summarized Objectives	Steps of the PSS methodology						
		S1	S2	S3	S4	S5	S6	S7
Understand	O1	0	0	0	0	0	0	0
	O2	0	0	0	0	0	0	0
Define	O3	0	0	0	0	0	0	0
	O4	1	3	0	1	0	0	0
	O5	0	0	0	0	0	0	0
Make	O6	3	9	0	9	0	3	0
	O7	0	0	0	0	0	0	0
	O8	0	0	0	0	0	9	9
	O9	0	0	0	0	1	3	0
	O10	0	0	0	0	0	0	0
Release	O11	0	0	0	0	0	0	0
	O12	0	0	0	0	0	0	3
	O13	0	0	0	0	0	3	0
	O14	0	0	0	0	0	9	0
	O15	0	0	0	0	0	0	0
	O16	0	0	0	0	0	0	0
	O17	0	0	0	0	0	3	3

The objectives of the phase Understand, O1 and O2, are not being achieved by any step of the PSS methodology. Having a specific phase to introduce the concepts of the initiative and guide the value proposition, the first toolkit phase proposes a reflection of how the company can build a CE through the business. But this aspect is not covered in the methodology. Then, when applying the PSS methodology [19], it is indicated to apply the methods proposed in the “understand” phase of the CE toolkit. By doing that, the company can be encouraged to comprehend what the circular flows are, to reflect on how it can be more circular in its value proposals, to enter the sustainable concepts to people involved in the initiative and to think about how the company can act according these concepts. Besides that, there is a specific method that proposes a reflection on how to apply servitization in company’s value proposals, which is directly related to the PSS strategies - although is not encompassed in the methodology. It is recommended to apply practical activities regarding the reuse of parts of products and that proposes inspiration based on agile process. Also, the nature can be used as an inspiration for finding solutions to company’s value proposals. The methods related to the achievement of the objectives O1 and O2 can be performed in the step S1 of PSS the methodology (value proposition).

Regarding the Define phase, objectives O3 and O5 are not being covered by the PSS methodology. The reflection about the company challenges and how the changes may affect the customers are not contemplated in the methodology. Thus, it is interesting for the company to design the circularity challenges and opportunities considering a product, service or business, and its impact in the system, customer and strategy. Additionally, the involvement of the team in order to align the goal and the CE approach is an important action when implementing the methodology. It can also be performed in the step S1 of the methodology (value proposition).

Other aspects to deal with in order to achieve the objective O5 are: to develop or redefine the business model from a circular design perspective, and create or review the brand using elements of circularity. The activities related to it can be carried out previously to step S1 (value proposition).

The objective O4 is partially embraced by the methodology, being related to the identification of the stakeholders that should be involved in the initiative, because the methodology comprises only the customers and not the internal team and other external participants, as indicated by the CE toolkit. So, the stakeholder mapping should be more explored by the methodology, which can be done during the steps S1, S2 and S4 of the methodology (value proposition, market analysis and use-case analysis, respectively).

Regarding the Make phase, the toolkit suggests the use of some techniques, such as surveys and use-case analysis. The methodology also mentions these tools, during steps S2 and S4, respectively, in order to identify the users across the whole system. This helps to meet, partially, the objective O6. On the other hand, the use of a user-centred research, as suggested by the toolkit in the phase “make”, could help to obtain a better understanding of user requirements.

The objective O7 of the toolkit is not covered by the PSS methodology. So, it is important to include the brainstorming technique to identify ideas around the principles of circularity. It can be performed in the step S1 of the PSS methodology (value proposition).

The objective O8 is totally covered by the methodology. The toolkit suggests the creation of a feedback mechanisms to recompile comments before release the product or service. In this regard, the methodology suggests the application of test and change management before launching the initiative.

Regarding the objective O9, the methodology presents a tentative to create a PSS architecture, but it does not encompass circularity. A prioritization of which circular concepts to take forward could be added in this step (S5, tentative architecture) based on how the concepts are related to the business strategy, and could consider how to mitigate risks. Also, based on the objective O9, the toolkit indicates the creation of prototypes to be tested before that substantial investments in material and labour are made.

Regarding the phase Release, objectives O10, O11, O15 and O16 are not covered by methodology. They encompass the identification of both technical and biological cycles, the partnerships, the use of design thinking approach to create a new value proposition and the involvement of the employees, respectively. So, the methods related to these objectives can be executed when the PSS methodology is applied. It can be performed by means of the step S1 of the methodology (value proposition).

The objective O12 is moderately covered by the methodology by means of step S7 (final definition). The planning of the pilot launch in the methodology covers only the changes needed to be performed after the tests and before the final launch of the PSS.

The definition of learning objectives for the pilot launching (O13) is superficially satisfied by means of the step S6 (test) of the methodology. On this, the criteria established for the pilot

launching are: facilities usage, performance, continuity and communication.

The planned versus reality of the PSS is analysed through feedback system, which is applied by the methodology and extremely embraces objective O14.

Finally, the objective O17 is moderately covered by the methodology on steps S6 and S7 (test and final definition), because it proposes the communication of the PSS business model, but without focus in circularity.

At the same time, the CE toolkit lacks some practical aspects of the transition to PSS, which are presented in Table 4. The first column presents the step of the methodology that indicates the main contribution to be included in the toolkit, which are described in the second column of Table 4. In summary, the methodology of Morelli [19] highlights the importance of identifying the competitors of the company, which is not a focus of the toolkit. Also, the methodology suggests the elaboration of a very detailed list of equipment and infrastructural required for the business, which is an aspect not mentioned in the toolkit.

Table 4. Elements of the PSS methodology for the CE toolkit

Step of PSS methodology	Contribution to CE toolkit
S2 – Market analysis	Competitors identification
S3 – Product-service definition	Elaboration of a very detailed list of equipment and infrastructural required for the business

5. Conclusions

The adoption of Product-Service Systems (PSS) methodologies is a promising pathway to support the shift to a circular economy (CE). The CE toolkit developed by EMF and IDEO, in turn, encompasses a set of methods to achieve the shift to CE.

The results demonstrate that the toolkit can complement the implementation of the PSS methodology of Morelli [19], since the toolkit indicates the methods to be used and the objectives to be achieved. Thus, applicants using the PSS methodology [19] could benefit from incorporating toolkit methods. Even the PSS methodology of Morelli [19] is research oriented than the toolkit, it had a higher frequency of application in real cases [13,19], allowing its evaluation regarding the CE toolkit.

As the toolkit encompasses a set of methods, it has a very practical bias. The methods are available on the internet, in a website, which facilitates its dissemination and propagation. Based on the analysis, the majority of toolkit methods should be incorporated by companies when the PSS methodology of Morelli [19] is implemented in order to achieve the objectives of the CE toolkit.

The toolkit indicates the use of alternatives related to end-of-life strategies as remanufacturing, reuse, recovery of components and materials, etc. These aspects are not encouraged by the methodology, but if applied they would help companies to make gains in the environmental, economic and social context. Since the majority of the toolkit objectives are not contemplated on PSS methodology, it indicates the importance of the initiative of EMF and IDEO in order to implement the methods in the companies.

On the other hand, the results show that the toolkit does not specify the main steps to implement the PSS, specifically, but presents an iterative methodology that involve understanding, defining, making and releasing to achieve the CE, directly related to PSS initiatives.

Finally, is important cite that the CE toolkit is a tool of design to circularity and PSS is a value within CE. In this sense, PSS can be incorporate in the CE toolkit to help the companies to develop new products that integrate services and can develop business models with vision in circularity.

The main limitation of the paper is the analysis of only one PSS methodology in the comparison with the EMF and IDEO's toolkit. Future researches can be directed to analyze other PSS methodologies. But, even though several alternatives of PSS methodologies are presented in literature, the methodology of Morelli [19] was selected because it is applied in real cases and presents sufficient details for the analysis carried out. Also, this methodology was provided by means of the work of Annarelli [18], which are the most recent systematic review of PSS.

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