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NEW PACKAGING SOLUTIONS IN FOOD SECTOR FOR CIRCULAR BUSINESS MODELS

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Purpose: The objective of the paper is to present some evidence from food packaging sector on the use of circular business models within their current products.
Design/methodology/approach: The paper explores the concept of circular business models from the perspective of its metrics and applicability. As an illustration the sector of food packaging is used. The objective is achieved through application of circular business models criteria to assess the parameters of new packaging materials and the way of developing them by selected companies. Carbon footprint (CF) methodology is used to estimate the environmental impact of new and currently used packaging. CF results are then used to feed circularity criteria together with circularity specific parameters. The set of environmental, economic and operational criteria is used to assess the circularity of business models applied in packaging sector.
Findings: The results of the assessment showed that there are different approaches or decision driving factors among analyzed cases. Some new packaging solution follow the circularity path mainly through achieving higher recyclability parameters. There are also solutions, that has more environmental or economic orientation with no visible development towards circularity.
Research limitations/implications: In order to get more reliable results it is advised to focus more on select types of food in order to get a better coverage on circularity supporting solutions. The limitation of the study is related to the lack of access to sensitive economic data, like costs of packaging, and therefore imperfect and not complex analysis of the issue.
Practical implications: The results of the assessment show clearly the circularity supporting decisions, as well as its relationship with environmental impacts. Such a dataset is certainly significant support for decision making within packaging and food manufacturing sectors.
Originality/value: The paper present original study over impact of specific packaging material innovation on circularity of business models. The study is addressed for science, academic and industry based stakeholders, as well as for public authorities and its actors, which are responsible for the optimization of packaging and waste flows.
Keywords: circular business models, packaging materials development, carbon footprint, packaging sector, circularity metrics.
Category of the paper: research paper.

1. Introduction

Circularity assessment criteria are fundamental in evaluating the sustainability and effectiveness of circular business models. Geissdoerfer et al. (2020) outline key criteria for circularity assessment, such as recycling measures, efficiency improvements, use phase extensions, intensifying use phases, and dematerialisation. These criteria aim to enhance material circulation, extend product lifetimes, and improve production efficiency to achieve circularity objectives. What's more important, these criteria needs adequate measuring and assessment framework that are done within specific and standardized tools and frameworks, including such tools as life cycle assessment or carbon footprint assessment (Nitkiewicz, 2021).

Additionally, Brändström & Eriksson (2022) introduce the Material Efficiency Metric (MEM) and Product Circularity Indicator (PCI) as criteria for evaluating circularity at the value chain and product levels, respectively. These metrics consider material flows, product lifecycles, and production efficiency to assess the circularity of business models.

Circularity assessment criteria encompass recycling measures, efficiency improvements, use phase extensions, intensifying use phases, dematerialization, material flows, product lifecycles, and production efficiency. These criteria are crucial for businesses to measure and enhance their circularity performance in alignment with circular economy principles. The circularity concept has highly dematerialization oriented priorities and therefore any product or packaging manufacturing issues gain additional importance (Wojnarowska et al., 2022).

Circular business models are increasingly recognized as a strategic approach for organizations to align with the principles of the circular economy. These models aim to create, deliver, and capture value through strategies that emphasize resource efficiency, waste reduction, and sustainable practices.

To evaluate the circularity of business models, tools such as the Circular Rebound Tool Das (2023) are developed to guide companies towards more sustainable circular business models. Artificial intelligence capabilities Madanaguli (2024) and dynamic capabilities Eechoud & Ganzaroli (2023) are leveraged as tools for innovation in circular business models, enabling businesses to adapt and thrive in circular economy contexts. Sustainability reports Ibáñez-Forés et al. (2022) are also utilized as tools for measuring and monitoring the transition towards circular economy practices within organizations.

Several common circularity criteria for business models have been identified in the literature:

1. Degree of Circularity: Circular business models are classified based on the degree of adoption of circularity principles, particularly in the customer value proposition and interface (Urbinati et al., 2017). Circular business models in the packaging industry often prioritize end-of-life management strategies, such as recycling and recovery, to ensure that packaging materials are reused or repurposed rather than treated as waste (Stewart, Niero, 2018).
2. Value Creation Logic: A key aspect of circular business models is the conceptual logic for value creation, which involves utilizing the economic value retained in products after their initial use to produce new offerings (Kanda et al., 2021). Another essential aspect of circular business models in the packaging industry is emphasizing circular product design. This involves designing packaging that is easily recyclable, reusable, or compostable to minimize environmental impact (Stewart, Niero, 2018).
3. Resource Efficiency: Circular business models aim to improve resource efficiency by extending the lifespan of products and parts, leading to environmental, social, and economic benefits (Frishammar, Parida, 2018).
4. Orchestrating Circular Networks: Effective circular business models often involve a focal actor orchestrating a circular ecosystem that includes suppliers, customers, research centers, and public authorities (Zucchella, Previtali, 2018). Establishing collaborative ecosystems within the packaging industry, involving stakeholders such as suppliers, manufacturers, and waste management companies, is essential for the successful implementation of circular business models.
5. Loop Closure Strategies: Circular business models are characterized by strategies that close, narrow, slow, intensify, and dematerialize material loops to reduce material inputs and waste leakage (Voukkali, 2023). Circular business models in the packaging industry often incorporate the use of reverse logistics systems to facilitate the collection and recycling of used packaging materials, contributing to a more closed-loop system (Guarnieri et al., 2020).
6. Innovation and Differentiation: Circular business models can help organizations increase differentiation, reduce costs, generate new revenues, and mitigate risks associated with resource scarcity (Husain et al., 2021). Developing innovative packaging designs that promote circularity, such as incorporating recycled materials or designing for easy disassembly and recycling, is a key aspect of circular business models in the packaging industry (Liu et al., 2023).
7. Communication Strategies: Effective communication with consumers regarding the disposal and end-of-life pathways of packaging materials is integral to circular business models in the packaging industry. Clear communication can guide consumers in proper waste disposal practices (Baskoro et al., 2023)

The common circularity criteria for business models revolve around integrating circular economy principles, emphasizing resource efficiency, fostering collaboration within circular networks, promoting loop closure strategies, and driving innovation and differentiation. By adhering to these criteria, organizations can develop sustainable business models that contribute to a more circular and resource-efficient economy. Circular business models in the packaging industry focus on end-of-life management, circular product design, supply chain circularity, communication strategies, reverse logistics, innovative packaging design, and collaborative ecosystems. By adhering to these criteria, companies in the packaging industry can enhance sustainability, reduce waste, and contribute to a more circular economy.

The objective of the paper is to present some evidence from food packaging sector on the use of circular business models within their current products. The paper explores the concept of circular business models from the perspective of its metrics and applicability. As an illustration the sector of food packaging is used. The paper explores the results of project titled "Functional & recyclable coated paper packaging for food products (REPAC²)", which was realized in 2022-2023 by consortium of Belgium, German and Polish partners. One of the major objectives of the project was to investigate the potential of the coated paper packaging for the food products with regard to its environmental impact and recyclability (Sirris, 2023). The objective of the paper is achieved through application of circular business models criteria to assess the parameters of coated paper packaging materials from REPAC^2 and explore the way of developing them by selected companies. CF methodology is used to estimate the environmental impact of new and currently used packaging. CF results are then used to feed circularity criteria together with circularity specific parameters. The set of environmental, economic and operational criteria is used to assess the circularity of business models applied in packaging sector.

2. Materials and methods

The methods used for the assessment are organized within two-step process. Firstly, LCA framework and its carbon footprint assessment is used in order to assess the environmental impact of different packaging materials. Environmental scores are subsequently used to feed circularity criteria.

The environmental assessment is made with Carbon Footprint method – namely Global Warming Potential (GWP) that was developed by International Panel on Climate Change (IPCC) in 2013 and later updated in 2021. This approach to the assessment of food product packaging is quite common, but the preference is to use more advanced variants of life cycle assessment. The method used for the assessment is IPCC 2021 GWP100 v. 1.01. The method takes the time horizon of 100 years as a point of reference. The method is based on

characterization of impacts, which are expressed in single unit of emitted kg of CO_2-eq. Impact factors within GWP100 are referring to the source of generated carbon footprint and include such categories as fossil, biogenic and land transformation sources (PRé Sustainability, 2022). The assessment is made in form of CF screening. The detailed assessment procedure is presented in one of the previous publication by Nitkiewicz et al. (2023).

The assessment of circularity is made on six innovative coated paper packaging for different food products. All the packaging are being considered for application to the food products that are listed in Table 1. For CS2, CS3 and CS6 the coated paper is the only packaging, while for CS1, CS4 and CS5 other packaging materials are used.

Table 1.
The list of products and its packaging

No.	Food product	Proposed Coated Paper packaging
CS1	diced salami	vacuum metallized paper
CS2	fruit rolls	acrylic- and vinyl copolymer CP
CS3	oil based crackers	extrusion coated Polyolefin
CS4	chocolate truffles	PVOH CP
CS5	dried herbs for tea	extrusion EVOH coated paper
CS6	chocolate tablet	coated paper with cold seal

In the following step the circularity of business models is assessed with the literature based circularity criteria. Due to data access limitation, the 6 out of 7 abovementioned criteria are assessed. Table 2 presents the circularity criteria and its characteristics. Each of the criterion is assessed with 0 to 5 scale, where 0 is lowest possible score while 5 is the highest score. The assessment is made with either quantitive parameters or qualitative parameters that are both transformed into ordinal parameters. The assessment is made on the basis of coated paper packaging parameters but also on the alternative packaging that is currently used. The implementation status is different for all the cases, varying from already implemented packaging (CS6), advanced testing of packaging line (CS2 and CS1), through analyzing the parameters of a packaging (CS4), to already abandoned solutions due to some operational or economic issues (CS3 and CS5).

Table 2.
Circular business model assessment criteria

Circularity Criteria [Acronym]	Characteristics	
	Description	Interpretation
Degree of Circularity [DC]	Share of packaging material volume that is recovered at end-of-life phase	The higher share of material volume that is recovered the better
Value Creation [VC]	Relative economic value of the remaining packaging. Level of meeting food product requirements.	The higher economic value of the packaging that remains after the use of the product the better. The higher level of meeting food product requirements the better.

Cont. table 2.

Resource Efficiency [RE]	Decrease of packaging weight, decrease of materials use in packaging manufacturing process	The lower weight of the packaging for transportation the better. The lower material use during packaging manufacturing process the better
Loop Closure [LC]	Share of closed loops within packaging life cycle	The higher share of the closed loops within packaging life cycle the better
Innovation and Differentiation [ID]	Share of recycled or repurposed content within packaging. Share of packaging CF in overall CF of product life cycle.	The higher share of secondary materials and resources the better. The lower share of packaging CF in overall product CF the better.
Communication Strategies [CS]	Number of material recovery streams	The lower number of material streams for recovery the better

It is important to notice that the current assessment is based on assumptions and not market related feedback. The criteria of degree of circularity, resource efficiency and loop closure are based on CF results, while the remaining criteria are assessed on the basis of packaging parameters itself or in relation to the currently used packaging of the product.

3. Results

The result section presents only the results of CF assessment and its related variables. In this paper we do not present life cycle inventory stage of CF assessment, which is presented in its complexity within REPAC^2 project websites.

3.1. Carbon footprint assessment of coated paper packaging

Functional unit for the assessment is 1 kg of packaging. The following life cycle phases are included in the study: supply of resources for manufacturing, packaging manufacturing, transport to distribution and end of life processing. Since the packaging is the functional unit for the assessment, the distribution and use phase are excluded from the assessment. It is justified with omitting the product within assessment, which is crucial for distribution and use phase. As mentioned before GWP100 method is used to calculate carbon footprint for the functional unit. The assessment is made within SimaPro 9.4 software.

3.2. Recyclability of packaging

The overall recyclability score is a qualitative parameter calculated on the basis of yield, visual impurities and sheet adhesion properties, expressed in %. Recyclability score can have values within the range of -100 to 100, and its score below 0 indicates that recycling in a traditional mechanical recycling process is not favorable. Additionally, sheet adhesion properties are assessed as coherent (could be recycled) and non-coherent (could not be recycled) and influence the recyclability score accordingly despite other factors.

3.3. Closed loops within packaging life cycle

Each packaging life cycle is analyzed within the waste flows and the possibilities to turn them into secondary flows. The classification as closed loops is dependent on the following issues: recyclability score of coated paper packaging, overall number of waste loops and share of closed loop within.

Table 3 presents the values of CF dependent parameters that are used to calculate circularity criteria. In the following step, the numerical parameters are transformed into ordinal parameters.

Table 3.
The values of CF related parameters for circularity criteria

Criteria	CS1	CS2	CS3	CS4	CS5	CS6
Overall CF [kg of CO_2 eq.]	5,04	1,31	1,51	1,53	0,87	2,99
Recyclability score [pts]	69	70	-10	89	-2	-21
Share of closed loops [%]	50	100	0	100	50	0

4. Conclusions and discussion

The results of CF assessment and interpretation of LCI parameters concerning recyclability scores, recycling content and share of closed loops are used to evaluate circularity parameters for investigated packaging. The remaining parameters are assessed on the basis of LCI data, CF results and additional insights on coated paper packaging, its alternatives and the technical and economic parameters of the packaging. The assessment is made by authors themselves. Table 4 shows the results of circularity assessment for investigated cases.

Table 4.
The assessment of circularity criteria for investigated packaging

	CS1	CS2	CS3	CS4	CS5	CS6
Degree of Circularity [DC]	4	4	1	5	2	0
Value Creation [VC]	4	5	2	3	1	3
Resource Efficiency [RE]	3	4	2	3	5	2
Loop Closure [LC]	3	5	0	5	4	0
Innovation and Differentiation [ID]	2	1	1	3	4	1
Communication Strategies [CS]	3	5	5	2	1	5
Average score	3,17	4,00	1,83	3,50	2,83	1,83

The results of circularity assessment should be interpreted from the perspective of food producers and packaging producers, as well as from the general perspective. As we could see the circularity assessment results only some of the cases could claim to have good circularity features or perspectives to achieve them. The assessment of business model circularity is certainly not complex while the assessment of single product / packaging is performed but it still gives some important insight on the situation. The coated paper based products have been developed in order to increase the recyclability level of waste packaging but it seems that this assumption is heavily dependent on the type of the coating that is applied. Certainly, the average recyclability is higher than the recyclability of alternative packaging, which regularly are some plastic based laminates, but it is surely not a constant variable.

The business models of food producers cannot be completely turned into circular through optimization of packaging only. Nevertheless, since the objective of the business entities involvement were to increase the recycling rate and decrease environmental impact, the optimization of packaging show significant potential for adopting to circular business models. It is important to notice that coated paper based packaging introduction is not automatically turning business model a circular one. Some solutions, like diced salami, fruit rolls and chocolate truffles have very promising results, but also, some of them showed that coated paper based packaging have still long road of development or even are not the proper way to circularity.

The perspective of packaging producers gives us even more ambivalent conclusions. The major conclusion could be that packaging material producers could turn into fully circular business models only together with food producers, or some other packaging users, that support the process along the way and help to find appropriate design of packaging. Food sector is very demanding in the sense of requirements, and has rather high entry barriers that include also practical know-how on cooperating with food producers on operationalization and application of specific packaging solution. Circular packaging could become a vital component of any circular business models within packaging sector, but still it needs to be accepted by food producers and for some part by consumers. It seems that the consumer awareness and their active contribution could be a vital point in closing the loops of packaging streams and moreover, to impact the food and packaging producers decision making (Koszewska, Zakrzewska-Bielawska, 2024).

There is also a strong commitment of different business sectors towards another scenarios of packaging material and life cycle development. It could be observed that some monomaterial solutions, often based on fossil plastics (Gasde et al., 2020) but also based on bioplastics (Baskoro et al., 2023), could also give some good circularity perspectives. The question that arises is if these type of solutions would be supported by regulatory framework.

In order to get more reliable results it is advised to focus more on select types of food in order to get a better coverage on circularity supporting solutions. The limitation of the study is related to the lack of access to sensitive economic data, like costs of packaging, and therefore

imperfect and not complex analysis of the issue. Introducing full set of parameters would certainly lead to better outcome and more reliable results.

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