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Portfolios of sustainable practices for packaging in the circular economy: an analysis of Italian firms

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Abstract

Purpose – This study analyzes sustainable practices adopted by Italian firms to enhance the circularity of packaging and related results in terms of environmental improvements.

Design/methodology/approach – The authors developed an empirical analysis using publicly available data from the National Consortium of Packaging (CONAI) in Italy, which consists of 603 circular packaging projects. The authors ran both descriptive and prescriptive analyses to determine individual sustainable practices and portfolios adopted to enhance packaging circularity and to verify related reductions in terms of CO2 emissions as well as energy usage and water consumption.

Findings – The findings reveal that firms are more accustomed to focusing on single sustainable practices than on portfolios of practices to achieve packaging circularity. Raw material saving and logistics optimization are the most frequent sustainable practices adopted by firms to improve circularity of packaging. The reuse of packaging allows firms to simultaneously reduce CO2 emissions, energy usage and water consumption. Preferences in terms of portfolio of sustainable practices are strictly linked to the types of materials used for packaging and environmental targets.

Originality/value – The authors investigate environmental practices that firms adopt to support packaging circularity, and the authors detect portfolios of sustainable practices that positively impact environmental performance indicators. This research extends a significant glimpse into the portfolio of sustainable practices for packaging in the circular economy implemented by firms, filling academic gaps and indicating business opportunities and avenues for economic development.

Keywords Circular packaging, Circular economy, Sustainable targets, Portfolios of sustainable practices, Life–cycle assessment, Empirical analysis

Paper type Research paper

1. Introduction

Owing to the pervasiveness of packaged products along supply chains, packaging is of considerable importance in achieving sustainable goals and targets (Fitzpatrick *et al.*, 2012). In recent years, the environmental impact of packaging has been frequently mentioned and discussed in the operations and supply chain literature (e.g. Verghese and Lewis, 2007; Verghese *et al.*, 2012; Pålsson and Hellström, 2016; Pålsson, 2018; Afif *et al.*, 2021; Cozzolino, 2022; Ripanti and Tjahjono, 2019), considering both traditional and e-commerce channels

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(Escursell *et al.*, 2021). Within this framework, García-Arca *et al.* (2014) developed the concept of "sustainable packaging logistics" according to which packaging must satisfy protection, commercial, logistical and environmental requirements. This leads to the perception of packaging as a strategic lever for achieving sustainable targets in terms of economic, social and environmental performance (Boubeta *et al.*, 2018). Packaging plays a role in several business phases including product development and design, purchasing, production, marketing and logistics (Min and Galle, 2001; Vernuccio *et al.*, 2010). Similarly, packaging plays a fundamental role in many activities in a circular economy (CE), including, at a minimum, packaging return, reuse and disposal (Meherishi *et al.*, 2019).

The debate on the impact of packaging on the natural environment has shifted toward a more holistic discussion of the impact of packaging life cycle throughout supply chains (Sarkis, 2003). According to a review by Silva and Pålsson (2022), research on packaging incorporates CE concepts. When discussing business issues linked to packaging, the CE has received widespread attention, and it has been researched as a concept linked to the "closing of the loop" in supply chains (Guide and Van Wassenhove, 2009; Hazen *et al.*, 2021) and "network design" in closed–loop packaging (Accorsi *et al.*, 2020). Furthermore, the CE is now included in the wider definitions of "circular green districts" (De Giovanni and Folgiero, 2022) and "circular supply chain" (Farooque *et al.*, 2019). For example, a circular supply chain needs at least a supply chain management design and relationship management enhancing firm performance from a CE perspective (Del Giudice *et al.*, 2021). Notably, a CE aimed at designing, making, using, collecting and treating packaging requires the implementation of a proper system to recover value from waste and the collaboration with other organizations and stakeholders, either within the same industrial sector or in different ones (Weetman, 2017; Farooque *et al.*, 2019; Zhang *et al.*, 2021).

The CE is increasingly recognized as a better alternative to the dominant linear (take, make and dispose) economic model (Farooque *et al.*, 2019). Starting with the waste pyramid model developed by the MacArthur *et al.* (2015) and continuing with the CE cascade model developed by De Giovanni and Folgiero (2022), the CE confirms its strategic importance and represents a valid business option for reaching sustainable development goals. Integrating the CE philosophy into supply chain management offers a new and compelling perspective on the sustainability domain (Farooque *et al.*, 2019) and reveals interesting potential in a competitive context and its measurement along the supply chain (Gammelgaard, 2019).

In particular, the CE of packaging includes strategies to extend product and packaging lifecycles (Kuo *et al.*, 2019) and turn residual value into something valuable through recycling (Bala *et al.*, 2020; Jalali *et al.*, 2020). There is also an emerging holistic understanding of potential opportunities in the pursuit of a more sustainable packaging design (Gustavo *et al.*, 2018), development and selection of ecofriendly packaging design solutions (Obrecht and Knez, 2017) and standardization of packaging (Ko *et al.*, 2012), which can create both environmental and economic gains in the transition to a CE (Meherishi *et al.*, 2019).

The development of a CE can guide future research and practitioners' efforts in designing packaging and using ad hoc practices along the supply chain (Meherishi *et al.*, 2019). In fact, packaging capable of achieving sustainable targets is supported through the development of guidelines, standards and scorecards that should be applied throughout the packaging life cycle—from production, through packaging, distribution and transport processes, to use and disposal (Kozik, 2020).

In the European Commission's document "CE Action Plan", one of the main building blocks of the European Green Deal for the new European agenda linked to sustainable growth, packaging is considered among the "key product value chains" with a high potential for circularity (European Union, 2020). Accordingly, the sustainability challenges posed by packaging value chains require urgent, comprehensive and coordinated actions that form an integral part of the European sustainable product policy framework and industrial strategy, contributing to the response to climate emergencies.

Considering the importance of the CE at the global level and its potential contribution to sustainable development targets, this study investigates the following research questions (RQs).

RQ1. Which environmentally sustainable practices for packaging circularity do firms adopt?

RQ2. Which portfolios of environmentally sustainable practices for packaging circularity lead to a reduction in CO_2 emissions, energy usage and water consumption?

The proposed RQs seek to fill research gaps that have emerged from an analysis of the scientific literature, which most likely investigates single cases by focusing on specific sustainable practices, performance indicators, packaging materials, or sectors. Accordingly, limited research has been conducted on the identification of sustainable practice portfolios aimed at packaging circularity. Furthermore, there has been limited analysis of the related impacts on either single performance indicators or batches of environmental performance indicators when considering the type of packaging materials. Therefore, this study brings together the identification of sustainable practices for packaging circularity and their impact on environmental performance.

To pursue the objectives of this study, after an international literature review, we used data available through the National Consortium of Packaging (CONAI) in Italy. CONAI offers consulting and supportive expertise to firms seeking to improve their packaging. Among the numerous projects CONAI has initiated, the "Circular Packaging" project has attracted the interest of both researchers and practitioners. It involves the evaluation of several practices to make packaging circular and analysis of their impact on environmental performance. We used public data available on CONAI's platform, which documents 603 cases and projects based on Italian firms that sought to make their packaging more circular and sustainable. Therefore, we conducted several empirical analyses to answer our RQs in the context of Italy in the last 10 years.

The remainder of this paper is organized as follows. Section 2 outlines the theoretical background and identifies the research gaps. Section 3 describes the research methodology. Section 4 presents an analysis and discussion of the findings, both descriptive and predictive. Finally, Section 5 summarizes the main theoretical insights and develops managerial implications and prescriptions. Section 6 concludes, highlights the limitations of this study and proposes some future research directions.

2. Literature review

Packaging has received significant attention in the literature on operations and supply chain management because of its impact on sustainability. Accordingly, Sonneveld *et al.* (2005, p. 4) presented the concept of "sustainable packaging", which is defined as packaging that is safe (non-toxic to humans and ecosystems), cyclic (recyclable or compostable), efficient (uses minimum materials and energy) and effective (adds socioeconomic value). Subsequently, this definition was reworked and refined, with emphasis on "life cycle", by other research and institutions such as the Sustainable Packaging Coalition [1] and the European Organization for Packaging and the Environment [2].

Although these definitions and concepts are continuously and significantly linked to a CE, minimal research has been conducted to bridge these two fields. In particular, academic literature on how firms adopt sustainable packaging practices from a CE perspective is limited. Specifically, rather than taking a broad approach to analyze practices necessary for sustainable and circular packaging, existing research has focused on the analysis of very specific cases, narrow in terms of materials analyzed, sector/market involved and /or type of packaging investigated. Furthermore, the life–cycle assessment (LCA) perspective is most frequently used methodology to study the implications of packaging.

To identify academic articles suitable for this study, a keyword search was implemented using the following filters: use of English language, academic journal articles and relevance to the topic focused on the implementation of packaging innovation cases for circularity.

Following a chronological order, Table 1 summarizes some studies from the academic literature that focus on sustainable practices for the circularity of packaging. It lists the possible sustainable practices for packaging and portfolios that have been investigated, measures of environmental impacts, materials analyzed in each research project and units of empirical analysis. This allows us to better document the existing studies in the related literature and properly highlight the research gaps that we aim to fill.

Considerable attention has been paid to the impact of packaging during its life cycle. Using an LCA, Ross and Evans (2003) examined whether CE practices such as reuse and recycling of packages made of plastic–based material reduced the quantity of landfill waste and overall environmental burden. Their study examined only two sustainable practices and one type of material (plastic–made).

Similarly, Dormer *et al.* (2013) investigated carbon footprint associated with plastic trays used as single–use food packaging. Using data from a plastic manufacturer, a cradle–to–grave study was conducted for trays produced from recycled polyethylene terephthalate (PET), calculating their product carbon footprint and analyzing how various parameters affect the carbon footprint. Many results have emerged, including the finding that significant carbon footprint improvements can be achieved by reducing the amount of raw materials used. In the same year, Toniolo *et al.* (2013) established a comparative LCA to evaluate how much an innovative recyclable package is environmentally preferable to an alternative package that is not recyclable, considering that both are made from recycled post–consumer PET bottles. The results show that the use of recycled materials combined with specific additives that ensure the recyclability of final products lead to better environmental sustainability. Both of these studies turned out to be very specific, as they focused on only one or two plastic products, while each of them analyzed single sustainable practices.

By studying a specific type of corrugated paperboard material used by a specific firm in the telecommunications sector, Dominic *et al.* (2015) discussed the CE relative to packaging design which should balance the need for product protection, material use efficiency and reduction in CO_2 emissions. They worked on the tradeoff induced by the usage of a certain amount of packaging material that led to product protection on the one hand and high packaging material waste on the other. This topic was also explored by Zhang *et al.* (2015), who analyzed returnable packaging management in automotive part logistics. Owing to their expanded life, returnable packages can reduce the total amount of materials and can be highly environment–friendly; however, they entail higher costs (e.g. procurement and transportation costs) than other packaging types. Dominic *et al.* (2015) and Zhang *et al.* (2015) focused on a single case study and explored the adoption of ad hoc sustainability practices in specific sectors.

Considering the case of aluminum cans, Niero *et al.* (2016) compared environmental impacts associated with different levels of two cradle–to–cradle (C2C) design frameworks and combined them with LCA. Their results revealed that increasing recycled content provided greater improvements in terms of environmental impacts than increasing renewable energy usage. Furthermore, receiving a higher certification level did not necessarily mean a reduction in environmental burden according to the LCA. Similarly, Saraiva *et al.* (2016) used LCA to compare environmental impacts such as greenhouse gas (GHG) emissions of reusable packaging using a polyethylene/natural fiber composite and cardboard material for mango fruit transportation; the study not only underlined the

Reviewed papers	Sustainable practices for packaging	Portfolio of sustainable practices	Analysis of the environmental impacts	Material analyzed	Unit of analysis
Ross and Evans (2003)	Lightweight, recycling and reuse	Lightweight with recycling; lightweight with reuse	Energy and emissions	Plastic	Analysis of single packaging
Dormer *et al.* (2013)	Reduce	Reducing	Carbon footprint	Plastic	PET food trays
Toniolo *et al.* (2013)	Recycling	Recycling	LCA	Plastic	Two plastic products
Dominic *et al.* (2015)	Reduction of waste	Reduction of waste and CO_2 emission	LCA (CO_2)	Corrugated paperboard material	Analysis of a single corrugated box for Ericsson product
Zhang *et al.* (2015)	Reuse	Reuse	–	Returnable plastic or metal packages	Analysis of single case in automotive parts logistics
Niero *et al.* (2016)	Recycling content, renewable energy	Recycling content, renewable energy	LCA and cradle–to–cradle (C2C) Certified™ Product Standard	Aluminum cans	Twenty different scenarios developed and compared for the case of aluminum cans
Saraiva *et al.* (2016)	Reuse and recycling	Reuse and recycling	LCA	Various materials in comparison (polyethylene/ natural fiber–composite and of cardboard material)	Analysis of single packaging (packaging dedicated to transportation of Brazilian mango fruits from producer to end–consumer)
Burek *et al.* (2018)	Lightweight and recycling	Lightweight with recycling	LCA	Various materials depending on the type of packaging	Analysis of single packaging
Casarejos *et al.* (2018)	Recycling	Recycling	Life cycle inventory analysis	Bioplastic packaging materials vs plastic	A case study of compostable cassava starch–based material and comparison with plastic material
Geueke *et al.* (2018)	Recycling	Recycling	–	Plastics, paper and board, aluminum, steel and multi–material multilayers	Commonly used food packaging materials, including plastics, paper and board, aluminum, steel and multi–material multilayers

(*continued*)

Table 1.
Summary of the literature and contributions in the field

Reviewed papers	Sustainable practices for packaging	Portfolio of sustainable practices	Analysis of the environmental impacts	Material analyzed	Unit of analysis
Postacchini *et al.* (2018)	Reuse and logistics optimization	Reuse and logistics optimization	LCA (aquatic ecotoxicity, terrestrial ecotoxicity, terrestrial acid/nutri, land occupation, global warming)	Glass	Analysis of single packaging (honey glass jars)
Joshi *et al.* (2021)	Waste management	Waste management	LCA	Plastic, lignite coal	Chemical analysis of materials
Kusch *et al.* (2021)	Recycling and Lightweight	Lightweight with recycling	LCA	Mixed plastics	Analysis of German waste management industry
This paper	Facilitation of recycling activities, logistics optimization, optimization of production processes, raw material saving, reuse of packaging, simplification of the packaging system, use of recycled material and other practices	All possible combinations among the sustainable practices for packaging	LCA — Energy, emission and water (individually and simultaneously)	Paper, plastic, steel, aluminum, wood and glass	Analysis of 603 Italian projects based on sustainable and circular packaging along almost 10 years

Table 1.

importance of reusable packaging but also showed the challenges that firms experience when dealing with the number of reuses necessary to reduce environmental impact.

Burek *et al.* (2018) evaluated various packaging solutions generally used in the milk industry and developed comparisons according to an LCA. Their analysis demonstrated that the adoption of lightweight and fully recycled containers can considerably improve environmental impacts. Casarejos *et al.* (2018) conducted a case study of a compostable cassava starch–based material. It included a life cycle inventory analysis of raw materials and product yields, water and energy use and GHG emissions as well as comparative analysis of petroleum–based and cassava starch–based packaging materials. Considering its low energy and water use, land use impacts and capture potential, it is clear that the production and consumption of compostable bio–based packaging from cassava starch has far better environmental outcomes than plastic packaging. In the same year, Geueke *et al.* (2018) focused on the chemical safety aspects of recycled food packaging, as recycling is currently considered an important measure in managing packaging waste. However, recycling may increase the levels of potentially hazardous chemicals in the packaging and—after migration—in the food itself. In their study of honey glass jars, Postacchini *et al.* (2018) demonstrated that the adoption of a packaging reuse policy along with logistical optimization can consistently reduce environmental emissions along the supply chain. The analysis considered five specific parameters of the LCA methodology: aquatic and terrestrial ecotoxicity, terrestrial acid/nutri, land occupation and global warming. All the studies we explored, which were published in 2018, presented some elements of wide analysis in terms of the typology of materials or environmental impact; however, they provided a rather limited overview of sustainable practices adopted by firms.

Joshi *et al.* (2021) conducted an LCA of a co–combustion system of single–use plastic waste and lignite coal to promote the CE. The sustainability and permeability of the novel co–combustion technique via co–processing were confirmed using the LCA results. From an energy standpoint, the co–combustion of single–use plastic waste and lignite coal is a feasible, safe and powerful option for an environmental–friendly waste disposal system. Using LCA on mixed plastics, Kusch *et al.* (2021) presented a model to determine the specific energy and material demands of lightweight packaging fractions and their respective climate impacts. Similarly, in comparison to all the studies that we reviewed, Joshi *et al.* (2021) and Kusch *et al.* (2021) focused on only one type of packaging material (plastic–made) and on specific cases and applications.

2.1 Research gaps

In the literature review, we have identified a few research gaps that we seek to fill with this study. Previous studies focused on single case studies which consider specific aspects of sustainable packaging for circularity linked to practices, performance impact, material, product and sector.

In Table 1, the columns labelled "Sustainable practices for packaging" and "Portfolio of sustainable practices" summarize the most frequently used practices in packaging, in a single way and as a portfolio. Accordingly, most of the literature has focused on the adoption of single sustainable practices to improve the circularity of packaging while seldom analyzing portfolios of sustainable practices focused in packaging circularity; when a portfolio of sustainable practices was studied, it was limited to two sustainable practices, for example: lightweight with recycling or lightweight with reuse (Ross and Evans, 2003); lightweight with recycling (Burek *et al.*, 2018; Kusch *et al.*, 2021), reuse and recycling (Saraiva *et al.*, 2016); and reuse and logistics optimization (Postacchini *et al.*, 2018). In contrast to literature, we develop an empirical investigation to identify the most frequently adopted sustainable practices for the circularity of packaging, as well as the portfolios of practices jointly implemented by firms.

Moreover, the literature shows that LCA is the most frequently used method for analyzing the environmental impact of packaging (Molina-Besch *et al.*, 2019), as showed in Table 1 in "Environmental impacts". In particular, LCA has been used to compare environmental impacts, such as water consumption, energy usage and CO_2 emissions, which have been analyzed in terms of packaging designs, materials, or systems (Almeida *et al.*, 2017; Toniolo *et al.*, 2013; Ross and Evans, 2003). We developed an empirical investigation using LCA to explore the impact of environmentally sustainable practices for circular packaging in terms of CO_2 emissions, energy usage and water consumption. In contrast to past research, we analyze the impact of the most frequently adopted practices, which are adopted either as standalone practices or as parts of a portfolio. The analysis was developed with a focus on a single sustainable impact and also simultaneously considering CO_2 emissions, energy usage and water consumption. Furthermore, the material used can have an important impact on the selection of sustainable practices for adoption; thus, the column "Material analyzed" in Table 1 is presented. Accordingly, we investigate whether the aforementioned impacts depend on the packaging materials adopted by firms.

Finally, while the analyzed studies mainly focused on either a single case or product in a specific sector, as highlighted in the column "Unit of analysis" in Table 1, our research seeks to develop more generalizable findings. From this perspective, we analyzed 603 cases characterized by different types of: materials used, economic sectors, firm characteristics, type of practices utilized and environmental impacts of their practices. Accordingly, the related empirical findings can be generalized to a wide range of companies focused on circularity of packaging.

3. Sampling and methodology

3.1 Sampling

To pursue the objectives of this study, we used data available through CONAI (The National Consortium of Packaging – COnsorzio NAzionale Imballaggi) in Italy. The data are linked to green practices adopted by firms to improve their sustainability indicators by focusing on the circularity of packaging. CONAI is a private non–profit consortium that monitors and ensures that Italian firms achieve certain recycling and recovery goals related to packaging waste, according to firms' targets and constraints imposed by law. Hence, it unifies firms into a unique entity that properly manages the recovery, recycling and valorization of packaging materials, specifically steel, aluminum, paper, wood, plastic, bioplastic and glass.

Among the various initiatives CONAI has undertaken, we used the data collected from the project "Eco–design for Prevention," through which it promotes structural changes in packaging and supporting prevention activities for firms via eco–design packaging. These are ingredients to engage in the CE of packaging and they consist of seven levers: "facilitation of recycling activities", "logistics optimization", "optimization of production processes", "raw material saving", "reuse of packaging", "simplification of the packaging system", "use of recycled material" and the residual category of "other actions" (such as, for example, the adoption of a certified environmental management system compliant with the standard laws). CONAI renders knowledge and expertise in these fields to promote sustainable development and a circular packaging economy.

CONAI has created a platform [3] on which all projects are reported and firms' actions are published. These include information on the aforementioned levers as well as environmental improvements realized in terms of CO_2 emissions, energy usage and water consumption. Our sample was composed of 603 successful cases of packaging innovation for circularity, the descriptions of which are displayed in Table 2.

The distribution of sectors is as follows: 39.8%, food and beverage sector; 8.3%, health care sector; 9.1%, home products sector; 42.8%, industrial sector. The distribution of employees is as follows: 29%, 50 or fewer employees; 25%, 50–249 employees; 15.6%, 250–500 employees; and 30%, at least 500 employees, respectively. Finally, the distribution of annual sales is as follows: 17.7%, lower than 7 million EUR; 14%, 7–20 million EUR; 18.7%, 20–80 million EUR; and 49.4%, at least 80 million EUR.

3.2 Methodology

We developed an empirical analysis of the sustainable practices that firms undertake to make packaging more circular. First, we identified the most frequent sustainable practices adopted

Sector		Number of employees		Sales	
Food and beverage	240	<50	175	<7million	107
Health care	50	50–249	153	7–20million	85
Home products	55	250–500	94	20–80million	113
Industrial sectors	258	>500	181	>80 million	298

Table 2. Composition of the sample

by firms to increase the circularity of packaging (RQ1-a). Second, we identified possible portfolios of sustainable practices for packaging circularity adopted by firms (RQ1-b). Third, we analyzed whether the portfolio of sustainable practices that firms adopted led to an improvement in single performance indicators (RQ2-a), which refer to reduced CO_2 emissions, energy usage and water usage; the analysis is then refined by considering the type of material the packaging is composed of (RQ2-b). Finally, we moved from the analysis of single performance indicators to a set of performance indicators and investigated the benefits of portfolios of sustainable practices for circular packaging in terms of simultaneous reductions in CO_2 emissions, energy usage and water consumption (RQ2-c).

We summarize the research design in Figure 1.

To pursue the objectives of this study, we employed a simple frequency analysis to derive state–of–the–art practices in Italy relative to the environmentally sustainable practices adopted to make packaging more circular (*Analysis 1*). Thereafter, we ran a correlation analysis to detect the portfolios of green packaging practices that firms currently employ (*Analysis 2*). We then conducted a set of regression analyses to predict firms' decisions about which sustainable practices to implement, considering the improvements obtained in terms of reductions in CO_2 emissions, energy usage and water consumption. To reach this target, we estimate a regression model that takes the following form:

$$Y = \alpha_Y + \beta_{YX} X_Y + \varepsilon_Y$$

where Y represents reductions in terms of CO_2 emissions, energy usage and water consumption; therefore, Y is the performance improvement after adoption of certain practices, measured in percentage. X represents the various environmentally sustainable practices for packaging that firms can adopt; they are given as follows: "facilitation of recycling activities", "logistics optimization", "optimization of production processes", "raw material saving", "reuse of packaging", "simplification of the packaging system", "use of recycled material" and "other actions". X is measured through a dummy variable that takes the value of "0" if a practice is not adopted and "1" if a practice is adopted. Finally, for each Y, we refer to α_Y, β_{YX}, *and* ε_Y as the intercept, coefficient of each sustainable practice and related errors, respectively.

Furthermore, we use two moderators linked to materials that have been the subject of packaging improvement. Our sample was most often composed of cases of packaging either

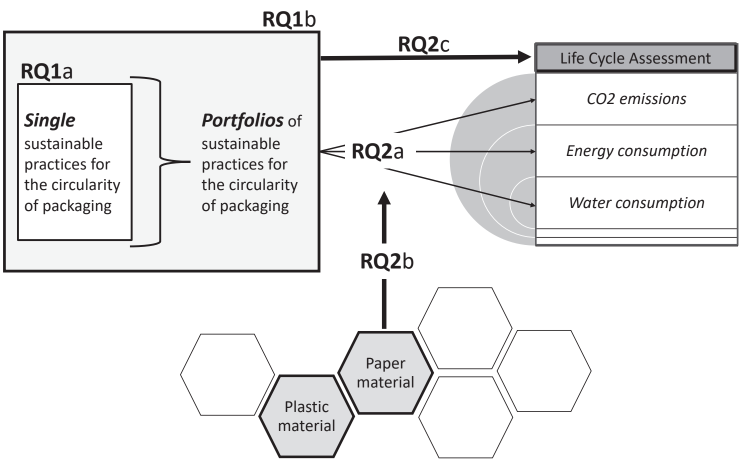

Figure 1.
Research design

in paper ($n = 245$ or 41%) or plastic ($n = 322$ or 53%) materials. The remaining cases of packaging are of other types of materials such as wood, steel, glass and aluminum. Therefore, the regression model was modified as follows:

$$Y^{\theta} = \alpha_Y^{\theta} + \beta_{YX}^{\theta} X_Y^{\theta} \theta + \varepsilon_Y^{\theta}$$

where θ refers to the type of material in question, either plastic–made or paper–made and is measured using a dummy variable.

Finally, we concluded the empirical analysis by identifying the relationships between sustainable practices for packaging and the tripartite of reduction in CO_2 emissions, energy usage and water consumption to evaluate average performance improvements of the cases of packaging innovation through green practices (*Analysis 4*).

4. Empirical results and discussion

4.1 Identification of the leading sustainable practices for packaging circularity (analysis 1)

To answer *RQ1*-*a*, we developed a descriptive analysis of the sustainable practices adopted to make packaging more circular, as shown in Figure 2.

Among the most commonly adopted practices, saving raw materials was found in 71% of the case of packaging. This outcome is consistent with the literature on procurement strategies, according to which procurement plays a key role in defining business success and guaranteeing a certain margin. Saving money through better management of raw materials is also a key ingredient of any CE strategy, according to which firms seek to save on the use of virgin materials. In fact, firms that undertake a circular economic strategy collect sufficient feedstock to fit their processes using returns and exploit their residual value rather than access new raw materials.

Logistics optimization was found in 34% of the sampled cases of packaging. The optimization of logistics is connected to both forward and reverse activities, which must be integrated and well–coordinated to guarantee that trucks and other logistics modes move with a full load, identify the shortest transport paths and minimize their environmental impact. Therefore, optimization of the logistics network is the second most important environmental practice that firms can adopt to become more sustainable. However, this practice can be very challenging for firms because it requires collaboration with other players and stakeholders, including specialized collectors and customers (Chen *et al.*, 2017).

Use of recycled material was found in 20% of the sampled cases of packaging. Several benefits can be obtained through that practice. Using recycled materials allows firms to reduce the amount of waste sent to landfills or incinerators. Therefore, firms contribute to the protection and conservation of natural resources, including water and minerals and prevent

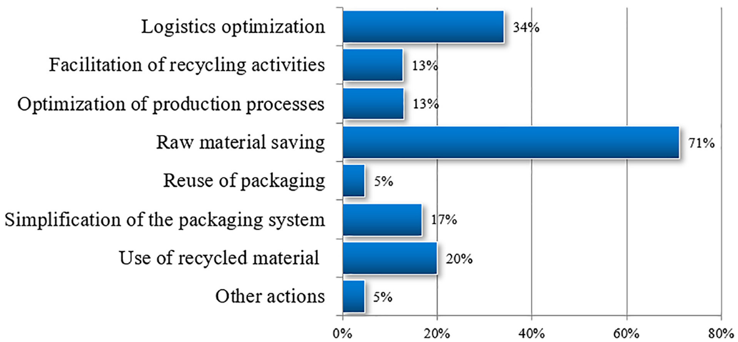

Figure 2. The most frequently adopted sustainable practices for circularity

pollution by reducing the needs, supply and procurement of new raw materials, thereby reaching energy savings objectives. This attitude implies that companies have invested a lot in designing products that can be easily recycled and contain a certain amount of recycled content. It should also be considered in future research the option of upcycling, which is a relatively new and unexplored method (Bridgens *et al.*, 2018; Cozzolino, 2022).

Simplification of the packaging system was found in only 17% of the analyzed cases. The adoption of this practice to achieve sustainable targets is only possible through technological developments related to the ability to create lighter and more efficient packaging solutions without necessarily reengineering the entire packaging. In practice, the development of lightweight packaging requires strong collaboration between manufacturers, wholesalers and sellers, as packaging is directly linked to marketing and selling strategies. In a competitive environment in which consumers are conscious and sensible about their packaging, setting up lightweight packaging to fulfill environmental targets while disregarding marketing and logistics implications may diminish consumer attraction, shipment efficiency and loading strategies. Therefore, lightweight packaging requires cost–efficient options that do not compromise quality and effectiveness while finding balance between over– and under–packaging, both of which can be detrimental.

This discussion is even more important in light of the outcomes of the reuse of packaging. This sustainable practice (observed in only 5% of the sampled cases) appears to have been disregarded; this implies that repetitive use of packaging is not often practiced. Therefore, a tradeoff emerges between the sustainability of the packaging and durability of its material; higher durability means higher chance that a packaging is reused. Firms should invest in the future to address this tradeoff, leaving room for future research (Mahmoudi and Parviziomran, 2020).

Finally, it is important to highlight the negligible number of cases of packaging related to production practices. In our study, optimization of production processes and facilitation of practices for recycling activities we observed in 13% of the analyzed cases. Interestingly, firms have probably already adjusted and upgraded their production processes in the past and are currently focusing more intently on logistics activities. This is a very important result for our study; the most responsible component in terms of environmental impact has historically been the production aspect (Fazekas *et al.*, 2019 [4]; Allenby, 1999). However, our findings move in the opposite direction and highlight companies' tendencies to focus on logistics activities; this tendency can be attributed to the considerable difficulties in accessing and collecting proper feedstock.

4.2 Searching for portfolios of environmentally sustainable practices (analysis 2)

To answer *RQ1*-*b*, we analyzed the portfolios of sustainable practices adopted by the sample of cases of packaging. We derived Pearson's correlation coefficients (r) among the sustainable practices, and they are displayed in Table 3. Coefficients in bold correspond to p–values (probability values) that are at least less than 0.05. When a p–value is less than 0.05, there is a significant correlation.

Through the correlation matrix, we observed that firms likely adopted and used one environmentally sustainable practice at a time, since the correlations are weak and mostly insignificant. To note, the following pairs have positive relationships: logistics optimization and raw material saving ($r = 0.135$); simplification of the packaging system and logistics optimization ($r = 0.154$). Therefore, firms are used to implementing either of the following pairs: logistics optimization and raw material saving, or logistics optimization and simplification of the packaging system. Intuitively, as firms implement raw material saving practices, they are also able to perform and better organize logistics by reducing the number of railway tracks, moving goods with fully loaded tracks and reducing the routing

	Logistics optimization	Facilitation of recycling activities	Optimization of production processes	Raw material saving	Reuse of packaging	Simplification of the packaging system	Use of recycled materials	Other actions
Logistics optimization	1							
Facilitation of recycling activities	−0.056#	1						
Optimization of production processes	−0.007	−0.029	1					
Raw material saving	*0.135**	*−0.184**	−0.038	1				
Reuse of packaging	0.034	−0.040	−0.064	*−0.216***	1			
Simplification of the packaging system	*0.154**	0.015	0.026	0.001	0.003	1		
Use of recycled materials	*−0.116*	0.056	*−0.144**	*−0.357****	*−0.093**	−0.058	1	
Other actions	0.007	−0.037	*−0.085**	*0.088**	−0.050	−0.036	0.027	1

Note(s): *p-value<0.05, **p-value<0.01, ***p-value<0.001, #underlined values are not significant

Table 3.
Correlation analysis on environmentally sustainable practices

distance. Similarly, by simplifying packaging systems, logistics operations are made simpler and faster.

In contrast, a negative correlation exists between logistics optimization and use of recycled materials *(r = −0.116)*. The latter requires many more operations and commitments from a logistics point of view, raising the question of whether the recycled material can be loaded together with virgin materials without being contaminated. These implications render the analysis of logistics difficult when recycled materials are transported.

Note that a negative relationship also exists between the facilitation of recycling activities and raw material saving (*r = −0.184*). This implies that firms save raw materials not through the implementation of facilitators for recycling activities but rather by implementing other sustainable practices, such as investments in technology, modifications of the transport fleet and the adoption of green materials. This result is corroborated by the negative relationship that exists between the use of recycled materials and raw material saving (*r = −0.357*), which highlights that virgin materials cannot be easily substituted by recycled materials.

Finally, our empirical analysis demonstrates that firms are more inclined to adopt one or two environmentally sustainable practices rather than a portfolio of such practices.

4.3 Portfolios of sustainable practices and improvements in a single environmental performance indicator (analysis 3)

While in Section 4.2 we searched for portfolios of sustainable practices implemented in the sampled cases of packaging, in this section we answer *RQ2-a* by identifying the portfolios of sustainable practices that should be implemented to achieve the ad hoc goals such as reduction in CO_2 emissions, energy usage, or water consumption. Furthermore, we answer *RQ2-b* by analyzing whether the aforementioned impacts depend on the type of packaging material that firms use.

4.3.1 Practices influencing reduction in CO_2 emissions and analysis of the materials. Our empirical results on CO_2 emissions, which are displayed in Table 4, show a portfolio of practices composed of logistics optimization, facilitation of recycling activities, optimization

	Improvements of the CO_2 emissions	Plastic material as a moderator	Paper material as a moderator
Intercept	0.164***	0.215***	0.181***
Size	−0.033	−0.057	−0.021
Sector	−0.043	−0.018	−0.069
Logistics optimization	0.062***	0.073	0.065**
Facilitation of recycling activities	0.154***	0.176***	0.157***
Optimization of production processes	0.046***	0.001	0.073*
Raw material saving	0.073***	0.061*	0.114***
Reuse of packaging	0.319***	0.285**	0.341***
Simplification of the packaging system	0.109***	0.143*	0.091**
Use of recycled materials	0.035	0.021	0.057
Other actions	0.014	0.049	0.024
Plastic material		−0.054	
Paper material			−0.052
R^2	0.291	0.180	0.178
Adjusted R^2	0.278	0.164	0.163

Note(s): *p-value<0.05, **p-value<0.01, ***p-value<0.001, #underlined values are not significant

Table 4. Practices influencing reduction in CO_2 emissions and analysis of materials

of production processes, raw material saving, reuse of packaging and simplification of the packaging system. The variables that are found to be insignificant are: use of recycled materials and other green practices. The use of recycled materials did not bring reduction in CO_2 emissions (β = *0.035*), likely because recycled materials have specific requirements including transportation, sorting, treatment and obtaining of recycled material, especially plastic, which still imply considerable CO_2 emissions. Therefore, in the future, firms should invest in green technologies to make the circularity of plastics less impactful for the environment in terms of CO_2 emissions. Other green practices, out of the seven practices identified by CONAI, did not bring reduction in CO_2 emissions (β = 0.014), as they mainly refer to administrative activities and regulations.

Instead, reusing the same packaging over time allows firms to significantly reduce CO_2 emissions (β = *0.319*) because of the savings obtained from not implementing new packaging such as pallets, hand–held containers, drums, tanks, boxes and straps. Indeed, the reverse logistics system is a key strategic lever, as customers should have the chance to return the packaging easily, safely and in good condition (Chen *et al.*, 2017). Our findings reveal that the use of optimization logistics techniques (β = *0.062*) supports the management of reverse logistics flows.

If packaging cannot be reused, it must be recyclable. Our findings confirm that firms should invest in facilitators to oversee packaging recycling (β = *0.154*) to reduce environmental damage, lower disposal investments and increase resource savings. By improving these activities, the facilitators contribute directly to the reduction of CO_2 emissions. For example, in recent years, firms have invested a considerable amount of economic resources in organic waste and bio–based plastic materials for packaging, which are most likely composed of vegetable materials that are fully compostable and biodegradable. This translates into a low usage of virgin material (β = *0.073*) whose CO_2 impact links to the entire packaging life cycle, including the suppliers. Furthermore, there can be substantial environmental impacts in terms of reduction of CO_2 emissions if the packaging is properly designed for the environment (β = *0.109*). Firms should apply lean practices to simplify the packaging and efficiently manage both the recovery and recycling phases. For example, an environmentally sustainable design means that it should be easy to remove labels from packaging, enable effective opening systems and guarantee the separability of the various components. In fact, lightweight packaging consists of creating lighter and more efficient packaging that is much more transportable and movable than non–lightweight versions without compromising the packaging quality or its effectiveness. Through the use of lighter materials, firms can reduce their CO_2 emissions during the manufacturing and transportation phases (β = *0.046*). For example, the X-Lite bottle from Sidel is the lightest bottle in the market, weighing 6.9 g compared to the average 12 g bottle. This advantage enables high–speed production and lowers the consumption of gasoline during transportation.

When analyzing the moderators, we noticed that all our findings were confirmed when the packaging was made of paper. Therefore, a portfolio composed of optimization of logistics, facilitation of recycling activities, optimization of production processes, raw material saving, reuse of packaging and simplification of the packaging system allows firms to reduce their CO_2 emissions when using packaging made of paper.

In contrast, our findings revealed that firms dealing with plastic packaging experienced greater difficulties in reducing their CO_2 emissions. In such cases, the portfolio of sustainable practices includes facilitation for recycling activities, raw material saving, reuse of packaging and simplification of the packaging system. In fact, recycling may require additional production steps when the plastic is not properly collected and treated, thereby requiring further inspection and sorting procedures that may increase emissions.

4.3.2 Practices influencing reduction in energy usage and analysis of the materials. As for CO_2 emissions, the variables were found to be insignificant when the practices adopted to improve packaging circularity and sustainability were the use of recycled materials and other green practices. Therefore, firms that make use of recycled materials and adopt practices that are different from those classified by CONAI will not realize any improvements in terms of their CO_2 emissions and energy usage.

According to our empirical results, as described in Table 5, the reuse of packaging allows firms to save substantially on energy usage ($\beta = 0.317$) due to the lower number of operations required because packaging production and purchasing are reduced if not totally eliminated. Furthermore, the simplification of the packaging system makes an important contribution to energy usage ($\beta = 0.107$) by reducing manual operations such as assembling packaging components and removing secondary packaging. Firms have reached this target by decreasing packaging weight, which is made possible by substituting the traditional protective material with special boxes, removing unnecessary packaging components and using new technological materials.

In most cases, energy usage can be reduced through investments for the innovation of production activities ($\beta = 0.103$), including the use of new and more efficient machines for packaging, reducing the scrap rate and improving material utilization. These activities increase the amount of material saved by firms in their production and logistics activities ($\beta = 0.077$), which translates to conserving and protecting natural resources. Energy savings were directly linked to logistics activities ($\beta = 0.04$) and facilitation of recycling activities ($\beta = 0.083$). On the one hand, the logistics optimization, such as the enhanced management of inventory and loading through ad–hoc packaging, reduction of logistics lead time and the integration of forward and reverse activities and related packaging, allowed firms to reduce their energy usage. On the other hand, given that recycling is a highly energy–intensive process, the facilitation of recycling activities allowed to reduce energy usage.

Finally, when firms deal with paper–made packaging, logistics optimization becomes less important while the use of recycled materials becomes the most effective practice. According to Arjowiggins, an EU Ecolabel company, for every ton of 100% recycled paper purchased

	Improvements in the energy consumption	Plastic material as a moderator	Paper material as a moderator
Intercept	0.153***	0.210***	0.175***
Size	−0.025	−0.052	−0.019
Sector	−0.054*	−0.031*	−0.063*
Logistics optimization	0.040*	0.050*	0.033
Facilitation of recycling activities	0.083***	0.091*	0.071*
Optimization of production processes	0.051*	0.020	0.071*
Raw material saving	0.077***	0.072**	0.123***
Reuse of packaging	0.317***	0.278**	0.307***
Simplification of the packaging system	0.107***	0.139*	0.092***
Use of recycled material	0.032	0.026	0.071*
Other actions	0.030	0.078	−0.028
Plastic material		−0.008	
Paper material			−0.044
R^2	0.247	0.152	0.137
Adjusted R^2	0.234	0.136	0.121

Note(s): *p-value<0.05, **p-value<0.01, ***p-value<0.001, #underlined values are not significant

Table 5. Practices influencing reduction in energy usage and analysis of materials

instead of non–recycled paper, 3.799 kWh of electricity can be saved. Our empirical findings confirm these results, thus providing firms with the rationale to adopt this practice. Similarly, the analysis of firms focusing on plastic–made packaging follows what we have mentioned previously in the analysis without moderators. The only exception is optimization in production, which probably results from the minimal influence modifications in the packaging have on production processes and their efficiency.

4.3.3 Practices influencing reduction in water consumption and analysis of the materials. As shown in Table 6, reduction in water consumption is possible when adopting a portfolio of practices that includes facilitation of recycling activities, optimization of the production process, raw material saving, reuse of packaging and simplification of the packaging system. Note that with regard to the analysis of CO_2 emissions and energy usage, the practices that firms adopt out of those suggested by CONAI do not lead to an improvement in water consumption. Furthermore, neither the logistics optimization ($\beta = 0.011$) nor the facilitation of recycling activities ($\beta = 0.028$) created a positive effect on water consumption. This may be because of the water use involved in these two practices. Logistics activities most likely have negligible water use. Similar results were found regarding the facilitation of recycling activities because water use in such processes (e.g. separate labels from goods, closing dispensers and removing the ink from packaging) is very minimal.

Among the previously mentioned environmental practices, the empirical analysis confirms some of the results obtained thus far in other sections. First, extending the packaging life cycle by reusing it several times resulted in a significant reduction in water consumption ($\beta = 0.319$). This result depends on the introduction of technologies to save water during the cleaning cycles and the amount of water used during packaging. According to Gustafson (2013), [5] the amount of water used when a bottle is manufactured can be up to six or seven times more than that stored inside the bottle. Therefore, a 1 L bottle may require 6/7 L of water to be made, hence highlighting the importance of adopting green practices such as reuse of packaging. At the same time, adopting practices leading to raw material saving directly leads to less water use ($\beta = 0.085$), which is achieved by creating lightweight packaging. Investments in developing new and more durable materials are needed to reach

	Improvements in the water consumption	Plastic material as a moderator	Paper material as a moderator
Intercept	0.196***	0.225***	0.211***
Size	−0.036**	−0.072	−0.008
Sector	−0.073***	−0.041	−0.115***
Logistics optimization	0.011	0.005	−0.015
Facilitation of recycling activities	0.028	0.100*	−0.079*
Optimization of production processes	0.062*	0.041	0.050
Raw material saving	0.085***	0.070*	0.110***
Reuse of packaging	0.319***	0.281**	0.324***
Simplification of the packaging system	0.129***	0.163***	0.100***
Use of recycled material	0.141***	0.097***	0.240***
Other actions	−0.006	−0.024	−0.092*
Plastic material		0.050	
Paper material			−0.031
R^2	0.228	0.126	0.137
Adjusted R^2	0.215	0.110	0.121

Note(s): *p-value<0.05, **p-value<0.01, ***p-value<0.001, #underlined values are not significant

Table 6. Practices influencing reduction in water consumption and analysis of materials

such targets, along with the substitution of virgin materials with recycled materials ($\beta = 0.141$).

Furthermore, firms can invest in process innovation to optimize production and reduce water use ($\beta = 0.062$). Process innovations include new packaging machines and/or conversion kits to ensure benefits such as reductions in water pressure and water flow. For example, firms making packaging for paintings insert a plastic bag inside the steel packaging to reduce the amount of water used during the cleaning phase. In fact, it is sufficient to remove the plastic bag and thereby obtain clean packaging. Indeed, decreasing water use also depends on the simplification of the packaging system, which is achieved by moving to a packaging design that uses fewer components and, ideally, packaging composed of a single component ($\beta = 129$). For example, Amazon and Procter & Gamble partnered to invent Tide Eco–Box [6], a concentrated version of Tide's traditional laundry detergent compressed into a fully recyclable, shipping–safe package. This solution requires 30% less water than conventional plastic jugs.

When we analyze the material, independent of variety (paper– or plastic–made), the previously mentioned portfolio can be adopted to reduce water consumption. However, the facilitation of recycling activities and other practices not suggested by CONAI lead to more water consumption. Also, the optimization of the production processes becomes insignificant, probably because the technologies available for paper packaging have been present in the Italian market for many years, and further investments to innovate such technologies would not yield additional improvements.

4.4 Portfolios of sustainable practices and improvements of multiple performance indicators (analysis 4)

While in Section 4.3 we searched for portfolios of sustainable practices for packaging circularity to improve a *single* environmental performance, we now search for portfolios to simultaneously reduce CO_2 emissions, energy usage and water consumption. Therefore, we seek to answer *RQ2-c*. Our analysis, which is reported in Figure 3, shows the improvements in

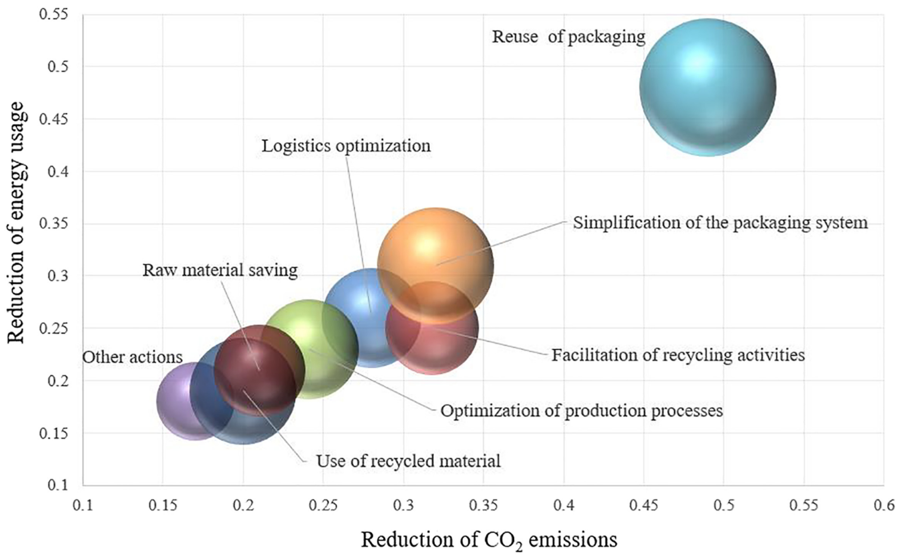

Figure 3.
The environmentally sustainable practices ensuring high sustainable achievements

the performance indicators, namely CO_2 emissions and energy usage on the horizontal and vertical axes, respectively. Each bubble stands for a unique sustainable practice, and its size indicates the improvement in water consumption.

Our analysis suggests that the best green practice is the reuse of packaging, which ensures an improvement in the tripartite environmental indicators, namely CO_2 emissions (whose average reduction is 49%), energy usage (whose average reduction is 48%) and water consumption (whose average reduction is 50%). This result implies that the most successful way to improve environmental indicators is to avoid creating waste. The materials that firms use must be extracted from the ground, transported to manufacturing plants and processed to create new products.

The second best green practice is the simplification of the packaging system, which yields a reduction in CO_2 emissions (whose average reduction is 32%), energy usage (average reduction is 31%) and water consumption (whose average reduction is 36%). Firms that have undertaken packaging simplification practices have invested in modifying the structure of their packaging to transport more products with one packaging unit by reducing certain parts of the packaging, thereby modifying the structure, improving the loading, shifting to mono–material packaging to improve recycling efforts and investing in process innovation to better organize the products during loading. These interventions have generated positive design changes such as lighter packaging leading to less energy usage during transportation, increasing packaging recyclability and consequently reducing landfill waste as well as improving space utilization over the production processes and inside warehouses. Furthermore, the simplification of the packaging system has led to the adoption of biodegradable and compostable materials, which have either a low impact on the environment through their capacity to be broken down by microorganisms during natural processes or an enhanced impact on the environment by becoming nutrients for the Earth.

Finally, we identified a portfolio of green practices including logistics optimization, facilitation of recycling activities, optimization of production process, raw material saving and reuse of packaging. This portfolio results in a moderate improvement for firms in water consumption (whose average reduction is 26%). Similarly, we notice that logistics optimization, facilitation of recycling activities and optimization of production processes also results in a similar decrease in energy usage (whose average reduction is 25%). However, these practices have significantly different effects in terms of CO_2 emissions. Logistics optimization and recycling facilitators result in an average reduction of 30%, whereas production optimization, raw material saving and recycled materials altogether yield an average reduction of 22%.

5. Theoretical insights and managerial implications

This analysis of 603 cases aimed at improving the circularity of packaging revealed that portfolios of practices are shifting from environmental practices linked to production to environmental practices linked to procurement and logistics. The most frequently adopted practices are raw material saving, logistics optimization, reuse of recycled materials and adoption of lightweight packaging solutions.

Surprisingly, we discovered a preference for implementing single practices rather than entire portfolios.

This result depends on a set of tradeoffs emerging from our research, as well as the operational and logistical challenges that firms face whenever they seek to integrate environmentally sustainable practices into their operations (Pålsson and Sandberg, 2020, 2021). Furthermore, some practices may require coordination with external parties, making management even more difficult.

Investigating the links between the portfolios of sustainable practices and individual performance indicators, we discovered that reusing the same packaging allowed firms to significantly reduce their CO_2 emissions, energy usage and water consumption. The reuse of packaging remains to be the most beneficial practice given paper– or plastic–made materials. But the composition of the portfolios may change as the type of material changes. The reuse of packaging was shown to be an effective sustainable practice resulting in simultaneous reductions of CO_2 emissions, energy usage and water consumption.

These findings provide empirical support to the waste hierarchy proposed by the Ellen McCarthur Foundation (2015) and later refined by Kirchherr *et al.* (2017), Reike *et al.* (2018) and De Giovanni and Folgiero (2022) on the "R-imperatives" framework in the context of a CE.

Simplification of packaging systems, facilitation of recycling activities and logistics optimization can also significantly reduce CO_2 emissions, energy usage and water consumption, but companies need to evaluate them on a case–to–case basis.

The research reveals that there is no "one–size–fits–all solution" for sustainable packaging. According to Berg *et al.* (2020), there are complexities and tradeoffs to consider in sustainability challenges to find the most effective route driving toward sustainability in packaging avoiding possibly temporary gratification from "quick wins."

Accordingly, our study may offer a roadmap for decision–makers, managers and policymakers who are involved at various levels in their organization and are interested in understanding the consequences of implementing sustainable practices to improve circularity of packaging, its products and their value along the supply chain.

In Table 7, we identify and classify the most effective sustainable practices in terms of CO_2 emissions, energy usage and water consumption. We also consider the type of material used in packaging. This table can help and support managers in building their own personalized portfolio of sustainable practices for packaging circularity and policymakers in promoting initiatives to support firms and supply chains in their sustainable evolutionary paths.

For example, a firm that seeks to reduce its CO_2 emission should focus on reusing packaging as the main choice of practice, followed by facilitation of recycling activities and simplification of packaging systems; these practices occupy first, second and third place in the ranking of best green practices. The portfolio changes with the type of material used. A firm that seeks to reduce its CO_2 emission while using paper–made packaging should focus on raw material saving, facilitation of recycling activities and reuse of packaging, in the order mentioned. A firm that seeks to reduce its CO_2 emission while using plastic–made packaging should focus on reuse of packaging, simplification of packaging systems and facilitation of recycling activities, in the order mentioned.

A firm that seeks to reduce its energy usage should focus on the reuse of packaging as the first choice, followed by simplification of packaging systems and facilitation of recycling activities; these practices occupy first, second and third place in the ranking of best green practices. The portfolio changes with the type of material used. A firm that seeks to reduce energy usage while using paper–made packaging should focus on the reuse of packaging, raw material saving and simplification of the packaging system, in the order mentioned. A firm that seeks to reduce energy usage while using plastic–made packaging should focus on reuse of packaging, simplification of the packaging system and facilitation of recycling activities, in the order mentioned.

A firm that seeks to reduce its water consumption should focus on reuse of packaging as a first choice, followed by simplification of packaging systems and the use of recycled materials; these practices occupy first, second and third place in the ranking of best green practices. The portfolio changes with the type of material used. A firm that seeks to reduce water consumption while using paper–made packaging should focus on the reuse of packaging, use of recycled materials and raw material saving, in the order mentioned. A firm that seeks to reduce water consumption while using plastic–made packaging should focus on

Table 7. Classification of environmental practices that improve packaging circularity and sustainability

	Classification of the best green practices			Best practices for paper–made packaging			Best practices for plastic–made packaging		
	CO_2 emissions	Energy consumption	Water consumption	CO_2 emissions	Energy consumption	Water consumption	CO_2 emissions	Energy consumption	Water consumption
Logistics optimization	5th	6th	No impact	5th	No impact	No impact	5th	6th	No impact
Facilitation of recycling activities	2nd	3rd	No impact	2nd	4th	To be avoided	3rd	3rd	No impact
Optimization of production processes	6th	5th	5th	6th	4th	No impact	6th	5th	5th
Raw material saving	4th	4th	4th	1st	2nd	3rd	4th	4th	4th
Reuse of packaging	1st	1st	1st	3rd	1st	1st	1st	1st	1st
Simplification of the packaging system	3rd	2nd	2nd	4th	3rd	4th	2nd	2nd	3rd
Use of recycling materials	7th	7th	3rd	7th	4th	2nd	No impact	No impact	2nd
Other green practices	No impact	No impact	No impact	No impact	No impact	To be avoided	No impact	No impact	No impact

the reuse of packaging, use of recycled materials and simplification of the packaging system, in the order mentioned.

A granular analysis of the impact of materials on sustainable practices reveals that companies can significantly change their preferences regarding which practices to adopt. Along with this consideration, our findings provide "best practice" suggestions that companies should implement based on both their sustainability goals and the type of materials of their packaging innovation. This point also leads to the importance of research and development activities toward alternative material solutions in packaging innovation, such as bioplastics (Dobrucka, 2019).

Finally, the analysis in Table 7 reveals that firms should adopt a portfolio composed of the reuse of packaging, simplification of packaging systems and raw material saving to simultaneously reduce their CO_2 emissions, energy usage and water consumption. This finding was consistent with that of the waste management hierarchy: this portfolio includes the most valuable options in terms of circularity, as they are positioned in the areas associated with reduce (simplification of packaging systems and raw material saving) and reuse (reuse of packaging) options inside the CE systems' solutions.

With this research, we embrace the CE perspective, promoted by the Ellen MacArthur Foundation, as a "systems solution framework" [7]. Only this broad perspective can successfully identify the criteria that will be consequently used to understand when and how individual and portfolios of sustainable packaging practices in light of different types of material used are preferable over others in terms of their sustainable impact on a firm and the entire supply chain throughout a product life cycle.

In the same regard, the investigated topic is a harbinger of further interesting insights that consider not only the "punctual" innovations but also, most importantly, the "systemic" perspectives that embrace different functions inside the firm and different actors that collaborate for packaging circularity along the supply chains. These actors include suppliers of raw materials, manufacturers of packaging materials, manufacturers of packaging machines, manufacturers of packaging, companies that use packaging, product design and graphic design agencies, communication agencies, prototyping and engineering organizations, researchers, logistic service operators, final consumers, operators in the disassembly and rework phase, trade associations, consumer associations and consortia. Consortia, as in the case of CONAI for Italy, may have the potential to facilitate the emergence of an "ecosystem" of complementary activities, resources and people working together to improve over time portfolios of sustainable practices for packaging in the CE.

Accordingly, the managerial implications arising from this empirical research cover a wide range of current practices and highlight the real impacts; hence, firms can take away strategic and operative directions from this study to realize a CE focused on packaging by considering both circularity in the original supply chain and across different ones (Farooque *et al.*, 2019; Zhang *et al.*, 2021).

The results of this research can support managers and policymakers who are working to fill the gap underlined by the European Commission to ensure that all forms of packaging in the EU market are reusable or recyclable in an economically viable manner by 2030, focusing on reduction in both (over)packaging and packaging waste and driving designs for packaging reuse and recyclability [8].

6. Conclusions

This study contributes to the field of the CE of packaging by investigating the sustainable practices adopted by firms to improve packaging circularity and reduce their environmental impact. These practices are linked to the expertise that CONAI offers to firms and society at large to improve the CE and the sustainability of packaging through sustainable practices.

Among the various practices for improving the circularity of packaging, the most popular practices suggested by CONAI and adopted by firms are the facilitation of recycling activities, logistics optimization, optimization of production processes, raw material saving, reuse of packaging, simplification of the packaging system, use of recycled material and other actions.

Using an empirical approach, we find that raw material saving and logistics optimization are the most frequent sustainable practices adopted by firms to improve packaging circularity (RQ1-a). Then, when seeking to identify portfolios of practices, we discover that firms are more inclined to adopt 1–2 or fewer environmentally sustainable practices rather than a comprehensive portfolio. In particular, firms generally implement the following pairs: logistics optimization and raw material saving, as well as logistics optimization and simplification of the packaging system (RQ1-b).

Next, we investigated the links between possible portfolios of sustainable practices and single performance indicators. We discover that reusing the same packaging over time allows firms to significantly reduce their CO_2 emissions, energy usage and water consumption (RQ2-a); this remains the same in the case of paper– or plastic–made materials, but the composition of the portfolio may change depending on the type of material. A granular analysis of the impact of the material reveals that it can change firms' preferences regarding sustainable practices they want to adopt (RQ2-b).

Finally, we find that in the majority of the sampled cases firms concentrate their investments on the reuse of packaging, which results in the simultaneous reduction of their CO_2 emissions, energy usage and water consumption. In fact, the reuse of packaging results is an effective sustainable practice independent of firms' goals, such as improving either one specific performance indicator or all of them simultaneously. The portfolio of practices including simplification of the packaging system, facilitation of recycling activities, and logistics optimization can also significantly reduce CO_2 emissions, energy usage and water consumption, but companies need to evaluate them on a case–to–case basis (RQ2-c).

Although this study offers some original and useful insights into the topic, it is not free of limitations. Herein, we report a list of possible topic directions to inspire future research in the same domain. We focused on Italian firms registered at CONAI, an Italian consortium that supports firms and people in properly managing and improving their packaging, with several projects aimed at sustainability, such as packaging circularity. Future research can replicate our study by either using a sample not belonging to CONAI, investigating a population of firms and projects from other countries, or focusing on specific sectors. Furthermore, we rely on environmental performance such as reduction in CO_2 emissions, energy usage and water consumption, as data for these are available on the CONAI's platform. Future research could also examine other types of environmental performance indicators (such as economic and social performance) or consider other sustainability practices to conduct a comprehensive analysis. While this study is based on desk analysis, future research may be developed in the field, such as through interviews with managers and/or policymakers who play active roles in the innovation of packaging toward circularity. Furthermore, the world is experiencing an important energy transition owing to global warming and several social issues caused by the COVID–19 pandemic. Future studies could conduct a dynamic analysis of these problems to investigate how firms adjust their packaging–related green strategies. Finally, future research could integrate the field of packaging circularity with digital technologies; these technologies connect physical objects that are sparse in an ecosystem, including packaging (Romagnoli *et al.*, 2023). Its use can increase the value of packaging information and improve circularity and related performance. These represent the research avenues that the authors are currently undertaking, and that they recommend to other interested researchers who may want to build upon the findings of this study.

Notes

1. https://sustainablepackaging.org
2. http://www.europen-packaging.eu
3. https://www.conai.org/en/prevention-and-eco-design/
4. https://ec.europa.eu/environment/enveco/economics_policy/pdf/studies/KH0319438ENN.pdf
5. https://www.npr.org/sections/thesalt/2013/10/28/241419373/how-much-water-actually-goes-into-making-a-bottle-of-water?t=1641286109242
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