
Knowledge co-creation for flexible packaging: learning from a case study

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Abstract

The capacity of enterprises to create knowledge throughout the innovation process has been pinpointed as a pivotal source of competitive advantage (Bierly et al., 2009; Grant, 1996). In recent decades, corporations have come to recognize that such knowledge creation cannot be confined exclusively within the organizational realm. In order to increase their pool of knowledge, businesses are progressively involving external stakeholders during the innovation process in the co-creation of knowledge (Hoyer et al., 2010; Mahr et al., 2014). Different studies investigated and illustrated the process by which enterprises integrate a specific category of external stakeholders into their

innovation processes (Horn and Brem, 2013). In particular, a current of research is dedicated to investigating the involvement of empowered consumers in such processes (Kazadi et al., 2016).

As far as innovation process is concerned, environmental or green innovation has been the main innovation focus of interest for many researchers (e.g. Amores-Salvado et al., 2014). Beyond the environmental aspects, several benefits derive from environmental innovation. For example, it allows to lower external costs (e.g., Beise and Rennings, 2005), allows the improvement of companies' efficiency, cost reduction, satisfies demand of environmentally friendly consumers, improves financial and business profitability (Amores-Salvado et al., 2014). However, Cainelli et al. (2015) have shown that environmental innovations are characterized by high levels of uncertainty, novelty and variety. Consequently, in such a context knowledge co-creation should have a fundamental role in facing the above mentioned challenges.

Based on these premises, the purpose of our study is to improve our understanding of how knowledge is co-created with consumer involvement in the environmental innovation process, and which technological capabilities a lead firm requires to manage this knowledge co-creation process. In addressing these issues, we conducted a comprehensive literature review on the topic of knowledge co-creation, followed by a case study involving an innovative startup operating in the development of flexible packaging.

Keywords – Knowledge co-creation, Flexible packaging, Startup, Case study

Paper type – Academic Research Paper

1. Introduction

The capacity of enterprises to create knowledge throughout the innovation process has been pinpointed as a pivotal source of competitive advantage (Bierly et al., 2009; Grant, 1996). In recent decades, corporations have come to recognize that such knowledge creation cannot be confined exclusively within the organizational realm. In order to increase their pool of knowledge, businesses are progressively involving external stakeholders during the innovation process in the co-creation of knowledge (Hoyer et al., 2010; Mahr et al., 2014). Through collaborative and competitive mechanisms, companies extend ideas for novel product designs, enhance functionalities, or address R&D challenges (Horn and Brem, 2013; Hoyer et al., 2010). Different studies investigated and illustrated the process by which enterprises integrate a specific category of external stakeholders into their innovation processes (Horn and Brem, 2013). In particular, a current of research is dedicated to investigating the involvement of empowered consumers in such processes (Kazadi et al., 2016).

As far as innovation process is concerned, environmental or green innovation has been the main innovation focus of interest for many researchers (e.g. Beise and Rennings, 2005; Rennings et al., 2006; Amores-Salvado et al., 2014). This is due to the fact that environmental innovation is considered as an important way to reach a better ecological, financial and economic situation in a cost-effective manner (Porter and Van Der Linde, 1995). It has been defined by Miranda et al. (2021) as “*the development of new or improved products and the creation of new processes and business models that bring benefits to the natural environment*”. In other words, it refers to new or modified practices, methods, systems and products to replace inefficient business activities and to decrease environmental harm (Kemp, 2000). Beyond the environmental aspects, several benefits derive from environmental innovation. For example, it allows to lower external costs (e.g., Beise and Rennings, 2005), allows the improvement of companies’ efficiency, cost reduction, satisfies demand of environmentally friendly consumers, improves financial and business profitability (Amores-Salvado et al., 2014). However, Cainelli et al. (2015) have shown that environmental innovations are characterized by high levels of uncertainty, novelty and variety. Consequently, in such a context knowledge co-creation should have a fundamental role in facing the above mentioned challenges.

The purpose of our study is twofold, and specifically (i) to improve our understanding of how knowledge is co-created with consumer involvement in the environmental innovation process, and (ii) which technological capabilities a lead firm requires to manage this knowledge co-creation process. In addressing these issues, our paper is based on a two-steps methodology: in the first step, we conducted a comprehensive literature review on the topics of knowledge co-creation and environmental innovation. In this step, we adopted both qualitative and quantitative methodologies to provide a well-rounded and in-depth analysis of the existing body of knowledge on the topics investigated (Cavana et al., 2001). In the second step, we realized a case study to provide some first evidence on the adoption of knowledge co-creation by innovative startups. Specifically, we purposefully selected a startup because there is a consensus in stressing that startups lack knowledge and skills necessary to address environmental issues (e.g., De Marchi and Grandinetti, 2013). Thus, knowledge co-creation relationships are critical for startups. More in detail, the startup investigated operates in the development of flexible packaging as our research setting. The rationale at the basis of this choice refers to the fact that, while the main purpose of packaging has always been to keep the product intact from producer

to consumer, the literature stressed that its role cannot be limited only to the protection one (Ampuero and Vila, 2006). The packaging is recognised to play a crucial role in enhancing the shopping experience and, consequently, brand recognition, as well as a tool for communicating the company's values and the great benefits that the product itself brings to the consumer. Thus, co-creation involving the final consumer is fundamental. Within this context, flexible packaging in particular meets these needs: indeed, in addition to being safe and sturdy packaging, it is modern packaging that captures the attention of consumers (Farrukh et al., 2022).

1.1 The context: flexible packaging

Packaging is recognized as playing a pivotal role in enhancing the shopping experience, bolstering brand recognition, and serving as a medium for communicating the company's values and the significant benefits of the product to consumers (Ampuero and Vila, 2006). Hence, involving the end consumer in co-creation becomes paramount. In this regard, flexible packaging is particularly well-suited to meet these requirements: not only does it offer secure and durable packaging, but it also presents a modern aesthetic that captures consumer attention (Farrukh et al., 2022).

Flexible packaging is a package or container made of flexible or easily yielding materials that, when filled or closed, can be readily changed in shape. They are used for consumer products to distribute a vast array of products. Flexible packaging may be constructed using any combination of the following materials: paper, plastic film, foil; and typically take the shape of a bag, film, lidding, liner, overwrap, pouch, rollstock, sleeve, or wrap. Thanks to advances in manufacturing, changes in consumer taste, and transformations in supply lines, flexible packaging has seen an uptick in recent years.

Many companies are starting to look into it as a viable alternative to rigid packaging. Flexible packaging has plenty of very real and very impactful advantages such as customisable, easier to transport and store in bulk, easier for marketing, inexpensive (Lange and Wyser, 2003).

The recent innovations in barrier function incorporated into plastic based packaging materials has allowed to flexible packaging the replacement of glass, metal containers. In particular, two different ways, either by adding a layer of barrier material or by mixing the barrier material into the base polymer shows the best solution to improve oxygen, water vapour and UV light barrier (Lange and Wyser, 2003). Oxygen and UV light are

the main causes of most food degradation processes. Oxygen promotes the oxidation of fats, the loss of nutrients and vitamins and the growth of aerobic microorganisms. UV light in particular can affect food quality generating free radicals by a number of organic photochemical reactions and can induce an early decrease of the food quality, altering food flavour and colour, promoting the degradation of vitamins, proteins and food antioxidants, and generating toxic substances (Goudarzi et al., 2017).

Even if the literature agrees in stressing the importance of involving the end consumer inflexible packaging co-creation, a search on Scopus databases with the keywords “flexible packaging” and “consumer*”, limited to the area Business, Management and Accounting, shows only 40 results. Moreover, giving a look to their distribution over time, all these results refer to the period 2000-2005, while a decreasing in the number of publications can be observed from 2006 to 2020. This trend can be justified considering that flexible packaging in the first decade of the 2000s experienced a significant industrial boost with the emergence of many multilayer films with high gas barrier properties, aimed at replacing typical applications of rigid packaging which achieved gas barrier through the high thickness of the material (Erlat et al., 1999).

Until a few years ago, flexible packaging was predominantly characterized by multilayers where multiple polymers were coupled, thus not ensuring recyclability. Conversely, the majority of rigid packaging consists of a single polymer and is theoretically recyclable. Recently flexible packaging industry is working on the use of recyclable material based on only one type of polymer but with the same barriers of multi-layered materials (Guerritore et al., 2022). This result will allow new improvements in flexible packaging studies starting from the possibility to reduce the use of plastic in flexible packaging respect to rigid packaging. Almost 90% less plastic usage compared to rigid packaging, which has led to a renewed interest in it.

2. Objective and research methodology

Our study aims to enhance comprehension regarding the co-creation of knowledge through consumer engagement within the environmental innovation process. Additionally, we seek to identify the technological capabilities necessary for a leading firm to effectively oversee this collaborative knowledge creation process.

To tackle these concerns, our paper employs a two-steps methodology (Figure 1): initially, we conducted a thorough literature review on knowledge co-creation. Employing a mixed research methodology based on both quantitative (bibliometric analysis) and qualitative (systematic analysis) methodologies (e.g., Kasmi et al., 2022), this step ensures a comprehensive and profound analysis of the existing literature on the subjects under investigation (Cavana et al., 2001). As for the former analysis (i.e., the quantitative one), bibliometric analysis are increasingly utilized to conduct comprehensive reviews of existing literature, providing a bibliographic overview of the extant literature and enabling the identification of key topics and pertinent findings (Ellegaard and Wallin, 2015). Moreover, bibliometric analysis is now frequently employed to scrutinize significant gaps within the literature, facilitating the identification of the most relevant subjects and outcomes. As for the qualitative methodology, systematic literature review aims to identify relevant primary papers, extract the required data, analyse, and synthesize results to gain further and broader insight into the investigated domain (Tranfield et al., 2003).

Subsequently, we conducted a case study to provide initial evidence on the utilization of knowledge co-creation among innovative startups. We opted to study a startup due to the consensus that startups often lack the requisite knowledge and skills to effectively address environmental concerns (e.g., De Marchi and Grandinetti, 2013). Consequently, forging knowledge co-creation partnerships becomes crucial for startups. Specifically, we selected a startup specializes in the development of flexible packaging, serving as the focal point of our investigation. The rationale behind this choice is due to the evolving role of packaging, which extends beyond mere product protection to encompass enhancing the overall shopping experience, bolstering brand recognition, and communicating company values and product benefits to consumers (Ampuero and Vila, 2006). Within this context, engaging in co-creation with end consumers is paramount. Flexible packaging, in particular, aligns with these requirements, offering not only robust and secure packaging but also contemporary designs that captivate consumer attention (Farrukh et al., 2022). In this regard, we conducted in January 2024 a deep interview with the startup CEO and its polymer scientist consultant (one of the authors of the paper). The interview was then transcribed and validated by the interviewee. The interview protocol is constructed from the literature on the topic.

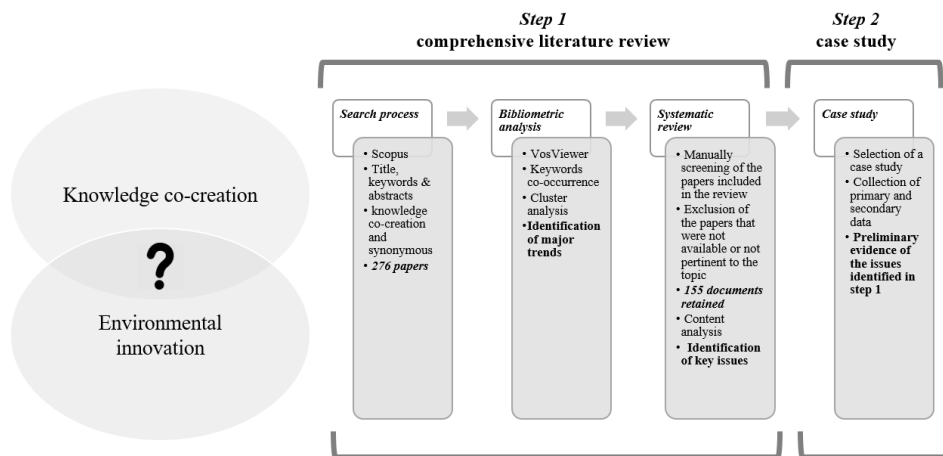


Figure 1 - Flow diagram of the methodology process

3. Findings

3.1 Bibliometric analysis

In this section, the results of some descriptive analyses are presented. The sample analysed comprises 276 scientific articles, of which 69% belong to the “Article” and “Review” types, 17% are articles presented and discussed at international conferences, and the remaining 14% are “Editorial”, “Book” or “Book chapter” and other types of documents. Figure 1 illustrates the time trend of scientific publications on the topic since 2001, the year in which the first article published on this topic was recorded.

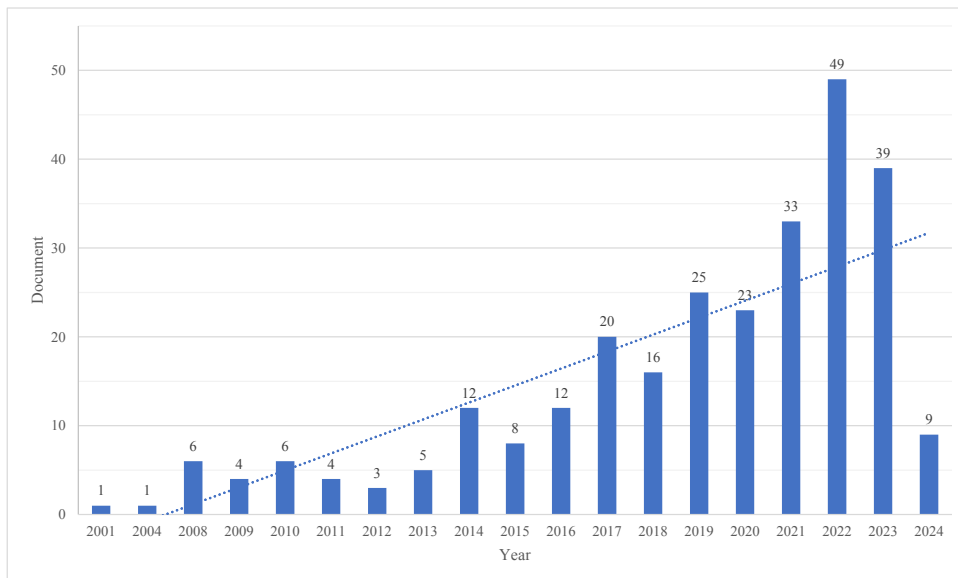


Figure 2 - The publication trend over the years

As can also be seen from the trend line, the topic shows a growing interest in the scientific community. In particular, looking at the last ten years, the number of publications has more than doubled. In fact, it rose from 12 scientific publications in 2014 to 39 publications in 2023. However, the peak of publications was recorded in 2022, with 49 scientific contributions.

Concerning the sources on which the 276 scientific articles were published, 221 different sources were identified.

Table 1 shows the top 3 sources that published the most on the topic. In first place are “Sustainable Science” and “Sustainability” with 6 publications each, followed by “Frontiers in Marine Science” with 5 publications and “Journal of the Knowledge Economy” with 4 publications.

Table 1 - Top five sources

| Source | Documents |
|--|-----------|
| “Sustainability” and “Sustainable Science” | 6 |
| “Frontiers in Marine Science” | 5 |
| “Journal of the Knowledge Economy” | 4 |

Among the countries with the greatest focus on the topic (Figure 3), the United Kingdom is the country with the most publications, with a total of 39 scientific articles. This is followed by the USA (28), Canada (25), Japan and Netherlands (23) and China with 20 publications. The other countries published fewer than 20 scientific articles on this topic. It is important to point out that countries are identified according to the affiliation of the first author, which also suggests which scientific communities are most dedicated to research on this topic.

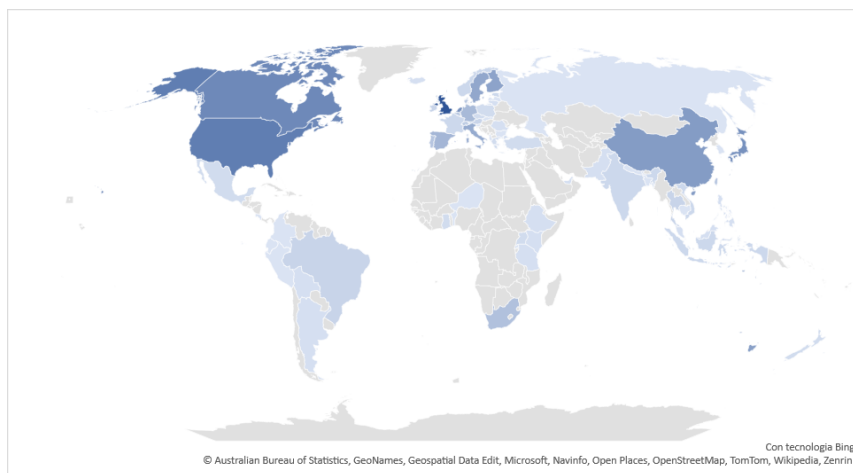


Figure 3 - Distribution of scientific papers in the world

With regard to the analysis of the most influential authors, Figure 4 shows the authors who have published more than three articles on the subject. “Kholhbacher F.” is the most active author on the topic, with 5 contributions, followed by “Shirahada K.” with 4 publications. The authors “Marques C.”, “Chen C.J.”, “Lin B. W.”, “Rodrigues E.M.”, “Ferreira J.J.P.”, “Barradas L.C.C.” and “Belal H.M.” all have three contributions each.

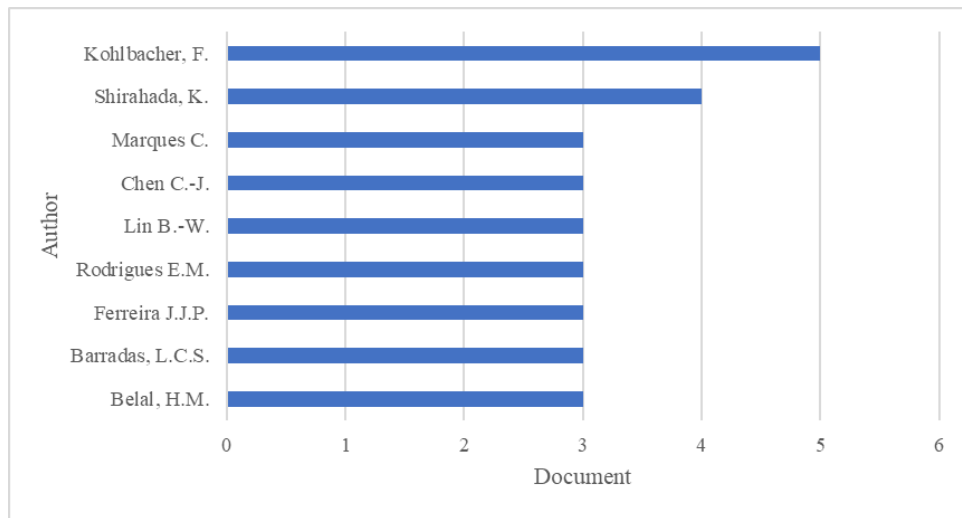


Figure 4 - Most relevant authors

VOSviewer software, an open access tool that focuses on the graphical representation of bibliometric maps, was used to conduct the keyword co-occurrence analysis. Figure 5 shows the network of the keyword co-occurrence analysis, in which five main clusters emerge. The five macro-areas investigated can be easily identified by the use of different colours in the network (figure 5). While the nodes identify the keywords and their size is proportional to the frequency of the keywords in the dataset under study.

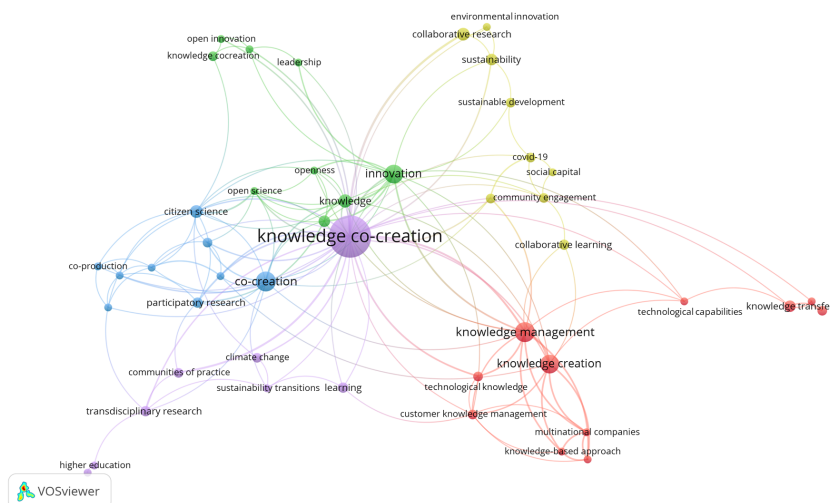


Figure 5 - Co-occurrence of keywords network (by VOSviewer)

The contents of the five identified clusters were carefully analysed, allowing them to be renamed as follows as shown in Table 2:

Table 2 - Results of Co-occurrence analysis: cluster identification

| Color of the clusters | Name of the clusters | Main keywords included |
|------------------------------|--|---|
| Green | <i>Open Innovation and Collaboration</i> | “open innovation”, “leadership”, “knowledge co-creation”, “open science”, “openness” |
| Red | <i>Actors</i> | “customer knowledge management”, “multinational companies”, “knowledge creation”, “technological capabilities”, “technological knowledge” |
| Yellow | <i>Sustainability and Environmental Innovation</i> | “sustainable development”, “environmental innovation”, “sustainability” |
| Purple | <i>Education</i> | “transdisciplinary research”, “higher education” |
| Blue | <i>Government</i> | “participatory research”, “co-creation”, “co-production”, “citizen science” |

Figure 6 highlights the temporal evolution of the five macro-areas investigated. Specifically, the darker colours (as indicated in the legend of Figure 6) highlight the concepts on which research has focused for the longest time, while the lighter colours identify topics of current scientific interest. It can be seen that the first concepts that characterise research in this area concern the cluster called “actors”. While the latest areas that the scientific community is focusing on are those related to the topics of “knowledge co-creation”, “knowledge transfer”, “collaborative research” and “environmental innovation”.

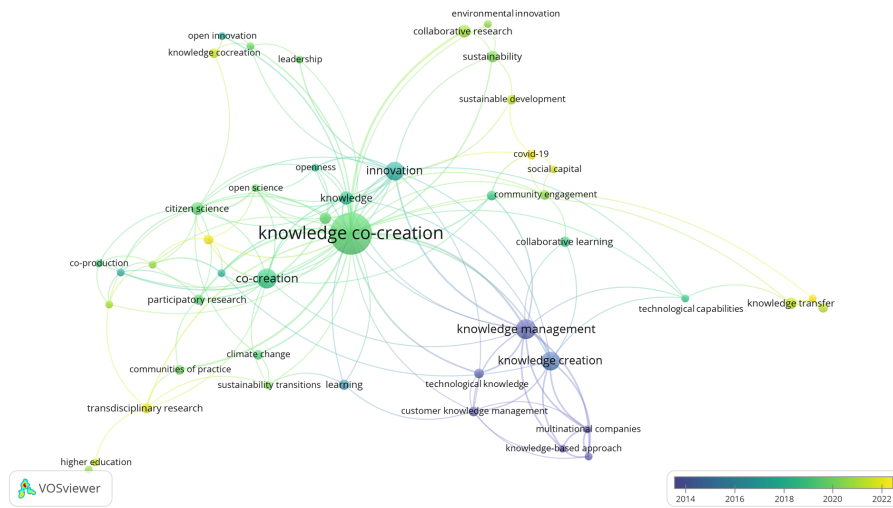


Figure 6 - Co-occurrence of keywords network - Overlay visualization (by VOSviewer)

This analysis allowed us to identify the major trends investigated in the extant literature on the topic on knowledge co-creation as well as to confirm a relationship exists between knowledge co-creation and environmental innovation. The bibliometric analysis, however, revealed the limitation of this kind of analysis to provide an in-depth investigation of the topic. To overcome this limit, a systematic review was carried out on a restricted sample of papers, as described in the following paragraph.

3.1 Systematic literature review on knowledge co-creation

155 papers were retained for the qualitative analysis after a manual screening of the titles and abstracts of the 276 publications. The reading of the 155 papers made it possible to classify each of the papers into one of the above mentioned clusters, as described in the following.

3.1.1 Green cluster: Open Innovation and Collaboration

Open innovation (OI) is a model of innovation that is based on the idea that organisations should seek out and embrace external ideas, as well as harness their internal expertise, to drive the innovation process forward (Chesbrough, 2006).

Collaboration is fundamental to OI and the broader concept of knowledge co-creation (Hysa and Themeli, 2022). In fact, knowledge co-creation is the process through which

people or organisations collaborate to generate new knowledge or innovation (Abbate et al., 2019). This concept is based on the idea that knowledge is constructed and enriched through the interaction and exchange of ideas between different stakeholders.

Knowledge co-creation can take place in various contexts, including research and development, design thinking, collaborative problem-solving and product or service development.

In summary, OI, collaboration and co-creation of knowledge are interconnected concepts that emphasise the importance of being open to external inputs (Su et al., 2015), of expanding corporate relationships (going beyond corporate boundaries) by involving actors from the external environment, and of sharing knowledge to stimulate innovation strategies.

3.1.2 Yellow cluster: Sustainability and Environmental Innovation

Environmental innovation is the process of developing and implementing new ideas, products, processes or practices aimed at contributing to environmental sustainability. This type of innovation focuses on reducing the environmental impact of human activities while simultaneously aiming to promote equitable and sustainable economic development. This approach embraces several strategies, including the adoption of cleaner and more efficient technologies, the improvement of production processes to reduce waste and emissions, and the promotion of sustainable natural resource management practices (Voytenko et al., 2016). It also supports the transition to a circular economy, which aims to minimise waste and maximise the reuse and recycling of materials. Knowledge co-creation emerges as a crucial element in the scientific research and innovation landscape. This collaborative process involves the interaction and exchange of ideas between different stakeholders, allowing a wide range of perspectives, expertise and resources to be harnessed to address complex and multidimensional challenges. Through knowledge co-creation, organisations can generate new innovative and sustainable solutions, promoting the adoption of more effective practices and policies in the context of environmental sustainability (Triste et al., 2018). This approach can be applied in a variety of contexts, such as research and development, public policy design, product and service development, and social and environmental problem solving. Furthermore, knowledge co-creation promotes collaboration and resource sharing,

encouraging the active involvement of all stakeholders in decision-making and implementation of solutions.

In conclusion, sustainability, environmental innovation and knowledge co-creation constitute three fundamental pillars in moving towards a more sustainable future for present and future generations. By synergistically integrating these perspectives and approaches, innovative strategies and solutions can be developed to address the environmental and social challenges of our time, promoting equitable, resilient and sustainable development for all.

3.1.3 Red cluster: Actors

In a context of knowledge co-creation, customer knowledge management is of crucial importance for multinational companies. These companies need to deeply understand the needs, preferences and behaviour of their customers in different global markets in order to offer products and services that effectively meet their needs. Through the analysis of customer data, feedback and interactions with the public, multinational companies can gain detailed knowledge of their customers, enabling them to customise their offers and improve the overall customer experience. Therefore, multinational companies must foster an organisational culture that fosters innovation and knowledge sharing to stimulate the creation of innovative and adaptable solutions to changing market needs.

Knowledge creation is a fundamental process for multinationals aiming to remain competitive in the global market (Civi, 2000). This process involves the generation of new ideas, solutions and knowledge through interaction and collaboration between employees, partners and other stakeholders.

Technological capabilities and technological knowledge are essential for multinationals operating in highly competitive global contexts, as they play a fundamental and strategic role within this particular ecosystem by enabling the translation of generated knowledge into practical and innovative solutions. These capabilities include access to and competence in the use of digital tools, technologies and resources that facilitate the creation, management and dissemination of knowledge effectively and efficiently. Through the synergistic combination of knowledge co-creation and technological capabilities, organisations can gain competitive advantages, accelerate innovation and address complex challenges in a collaborative and proactive approach. Multinational companies need to invest in training and developing the technological capabilities of their

employees to fully utilise the potential of emerging technologies and maintain a competitive advantage in the global market.

In synthesis, in the context of knowledge co-creation, multinational companies need to effectively integrate and combine customer knowledge management, knowledge creation, technological capabilities and technological knowledge to promote collaboration and knowledge sharing among employees, partners and other stakeholders. The organisations that are able to combine these dimensions can adapt nimbly to changing market dynamics and maintain a sustainable competitive advantage in the long run.

3.1.4 Blue cluster: Government

Citizen science is a concept that has received various interpretations in the literature and represents a fundamental phenomenon in the contemporary landscape of scientific research and social innovation. Knapp et al. (2019) define it as the “philosophy of public involvement in scientific discourse and policymaking”, thus emphasising the active role of citizens in decision-making about science education and research. Similarly, Bonney et al. (2009) describe it as the “process and practice of non-scientists collaborating with professional scientists to collect, transcribe, categorise and/or analyse data”, highlighting the collaboration between experts and non-professional individuals to perform scientific activities. Citizen science emerges as a tangible exemplar of knowledge co-creation, which is based on a collaborative process involving a broad spectrum of actors in scientific research and competence development. These collaborations not only promote the production of new knowledge, but also the science education of society as a whole (Shirk et al., 2012; Knapp et al., 2019; McKinley et al., 2017).

Moreover, citizen science is a powerful tool to promote greater public participation in scientific research and decision-making (Danielsen et al., 2010). By involving ordinary citizens in the collection and analysis of scientific data, this approach democratises access to scientific knowledge and increases society’s trust in science and technology.

In conclusion, citizen science not only facilitates the co-creation of knowledge, but also the creation of innovative and sustainable solutions to global challenges (Ciasullo et al., 2022). This approach is an excellent example of how collaboration between experts and citizens can lead to significant results in science and society.

3.1.5 Purple cluster: Education

In the context of knowledge co-creation, higher education and transdisciplinary research both play a key role in facilitating collaboration and the shared construction of knowledge (Owusu-Agyeman et al., 2019).

Higher education provides a learning and research environment where students, faculty and researchers can interact and collaborate to address complex challenges and stimulate innovation. Universities act as knowledge centres (Owen et al., 2023), facilitating the transmission and creation of knowledge through academic courses, research labs and collaborative projects. In this context, knowledge co-creation is promoted through the interaction between different academic disciplines, encouraging the synthesis and integration of different perspectives to address complex issues.

Transdisciplinary research focuses on the collaboration and integration of different disciplines to address real-world problems (Lawless et al., 2024). This approach crosses the traditional boundaries of academic disciplines, integrating knowledge and methodologies from multiple fields to provide innovative and sustainable solutions. Transdisciplinary research often involves not only academics, but also external stakeholders (Thompson et al., 2017) such as practitioners (Wanner et al., 2021; Giebels et al., 2020), decision makers (Giebels et al., 2020) and community members (Pineo et al., 2021), thus promoting broader involvement in the generation of knowledge and its practical application.

In the context of knowledge co-creation, higher education and transdisciplinary research complement each other, creating a productive environment for innovation and the development of innovative solutions to global challenges. Through cooperation between different disciplines, academic institutions and external actors, it is possible to make the most of available knowledge and resources to tackle complex problems in a collaborative and proactive manner. In this way, a culture of knowledge co-creation is fostered that encourages collaboration and synergy between different actors for the common good.

3.2 Case study

3.2.1 Idea generation and innovation development

We analyzed the startup Packstyle, belonging to Cimpress, a global leading multinational in online mass customization (Web-to-print).

The idea came from the request to the multinational company to have customized flexible packaging for small runs. In this sector, the traditional machines have high operating costs and work only on large orders of food brands or manufacturers. The startup was created to satisfy a new niche market, that of small businesses that need packaging for their products but demand limited runs and in a very short time. The driving force came from the innovation culture of the parent company and the availability of one of his largest supplier who had a machine to do experimentation on digital printing in flexible materials.

At the beginning, the founding team didn't have the expertise on flexible packaging. The founders acquired knowledge by attending conferences organized by national associations or institutions of the packaging industry. The startup accumulated knowledge in food safety, certification and polymers by collaborating also with a polymer scientist consultant.

Thanks to the prestige of the parent company, the startup creates working teams with major printing, post-print and finishing packaging companies and with material suppliers. In this way, each actor offers its knowledge to the working team in order to find industrialized solutions in the shortest time. Primarily, experimentation regarding recyclable monomaterial was conducted with polyethylene (PE) with EVOHs as barrier films. The route turns out to be complex, due to the variables that cannot be governed in production process (above all high temperature). Hence the choice to work with other polymers such as PP (polypropylene) for recyclable packaging and other bio polymers generated from plant waste (for biodegradable and compostable packaging).

The goal of the new proposal of EU regulation for Packaging and Packaging Waste (PPWR) is to reduce packaging waste per capita in each member state by 15 % from 2018 levels by 2040 through packaging reduction, reuse and recycling. From January 1, 2030, all packaging on the market must be designed to be recyclable. Some measures are aimed at preventing waste generation upstream by eliminating unnecessary packaging, promoting reuse and refilling, and setting targets for the use of biodegradable and compostable materials. Using bio-based materials for packaging is a sustainable

innovation also imposed by the European regulation. The startup, with the support of the polymer scientist consultant, finds important new materials suppliers with whom to do experimentation even on limited quantities. The broad participation of major companies with R&D Department and their involvement was due not only to the professional relationship with the parent company but also to the interest in such an innovative proposal as the one made by the startup.

The founding team, composed by two managers, built and managed a network of suppliers of materials and machinery, with which co-creating knowledge for the environmental innovation.

"The startup has found a great willingness to collaborate, to dialogue in the working teams, because every actor of the project brings something home. Curiously, the biggest difficulty in working together is crossing agendas. The startup is seen by these large companies as a kind of laboratory where they all do experimentation together, in which to work in unknown areas and have a concept of replicability of error and mitigation of error that they would not have in other situations. The startup has combined expertise to do innovation. There are no secrecy agreements, no secret chemical formulas, no patents, we rely on the ethical relationship that exists between client and consultant. Knowledge can be open because we are operating in a new market" (the startup CEO).

The founding team had in-house expertise to manage the new business and after one year, the startup began experimentation with a coffee company, entering the food industry and then the nutraceutical industry. Tests on the organoleptic properties of coffee determined that the product in the startup's pouches had not been altered. In addition, European institutes confirmed the high recyclability of the monomaterial pouches. The startup's investment in R&D is about 20 percent of turnover.

3.2.2 Innovation with consumers

The startup's environmental innovation is also a marketing innovation. The customization of sustainable packaging, is appealing to new niche markets. According to the startup's business model, packaging graphics are co-created with the customer. The need to comply with certain production limits and the lack of skills in the industrial printing process on the part of its customers and their graphic designers, requires the startup to develop training-informative paths also on the recent European legislation. The startup has a technical sales team that plays an advisory role by accompanying the client

through all stages of design and production. "Sometimes the client does not know the barriers of the product, so together we study the solution: what product should be bagged, with what characteristics, what it should be protected from, for how long, what distribution chain it is subjected to" (the startup CEO). The startup also trains consumers on the graphic part, with dedicated webinars, accompanying them to the creation of the own pouch. The experience gained by the startup is made available to the client, who is considered a partner. "This customer oriented approach is yielding far more success than simply placing the product on a web portal. Today the startup has 35 employees all very young with a university profile in materials science and food safety. The most difficult challenge is finding specialized staff and keeping motivation to work high" (the startup CEO).

4. Conclusions, discussion and future research

Our paper, based on a two-steps methodology, allowed us to shed light on the topic of knowledge co-creation within a specific context, that is the flexible packaging one.

The first step (i.e., the literature review), by analysing the extant literature on the topic under investigation, confirmed the importance knowledge co-creation within an innovation process (green cluster), and specifically the importance of being open to external inputs as well as external actors. Among all, customer (red cluster) and citizen (blue cluster) play a central role. Also Universities, acting as knowledge centres, are important (purple cluster). As for the inputs, technological capabilities and technological knowledge are the most important, in particular for the bigger companies (red cluster). Finally, both the bibliometric and systematic reviews, highlighted the relationship between knowledge co-creation and environmental innovation. Indeed, the yellow cluster highlighted the three fundamental pillars (namely, sustainability, environmental innovation and knowledge co-creation) to be considered in order to be sustainable.

The case study analysis (second step) allowed us to answer the two research questions as follows.

RQ: What technological capabilities a lead firm requires to manage the innovation co-creation process?

The case study demonstrated that it is possible for a startup to initiate a technological environmental innovation even without in-house technological capabilities. The literature

has shown that the technical skills of the founding team are key determinants of innovation success and that firms with higher technological capabilities prefer cooperative R&D, while those with lower technological capabilities tend to choose internal R&D (Wu et al., 2020). In contrast, the case study pointed out that the startup, belonging to a multinational group, can develop innovation just managing networks with major suppliers of materials and machinery for knowledge co-creation. The acquisition of knowledge and technical skills occurs following an intensive period of study and experimentation. Being part of a multinational corporation puts the startup in the privileged position of being able to study and to do so with the best companies in the field, without having to face problems of scarcity of resources. But what joins the network companies is not only an established relationship of trust and esteem with the parent organization but also the innovativeness of the proposal. Innovativeness imposed by the new European packaging regulation, which incentivizes proposals for flexible packaging and packaging with waste and biodegradable materials.

RQ: How knowledge is co-created with consumer involvement in the environmental innovation process?

In the development stage, the startup manages networks with suppliers to co-design innovation, while in the commercialization stage, the startup transfers accumulated knowledge to consumers in order to co-create a finished, customized product. The ability to orchestrate external resources, especially during the different stages of a startup's life cycle, and to manage networks for co-creating innovation becomes determining factors for its growth in the competitive landscape (Marcon and Ribeiro, 2021, Melander and Pazirandeh, 2019). The availability of small batches of packaging, their customization through graphics, and delivery within a short time frame are the value proposition the startup has developed to open a new market in the flexible packaging industry. However, the involvement of consumers, in the development stages of their own packaging requires their education through webinars and consulting services at all stages of development. Despite the limitations of a case study, as particular as that of a startup belonging to a multinational corporation, some practical implications can be deduced from what has been reported.

Our analysis allowed us to identify interesting future research. As first, the extant literature provides numerous instances illustrating the challenges that emerge when diverse actors collaborate to co-create knowledge within the environmental innovation

process (e.g., McCauley and Stephens, 2012; Klenk and Hickey, 2012). Future studies should be carried out to gain a deeper understanding of knowledge co-creation and exchange within environmental innovation, as well as the barriers and facilitators associated with them.

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