BARRIERS AND KEY ENABLERS OF ACHIEVING A FIBRE-BASED PACKAGING RECYCLING TARGET OF 90% IN EUROPE

A producer case study investigating the barriers and key enablers in regard to increasing cellulose fibre-based recycling rates within the packaging industry.

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ABSTRACT

This study explores the key hurdles and facilitators of reaching a 90% recycling target for fibre-based packaging in Europe using the Grounded Theory approach, through qualitative interviews with industry professionals. The research reveals critical factors, including recycling infrastructure, collection and sorting systems, paper product recyclability, and public awareness. The need for expanding Paper for Recycling (PfR) collection, especially in underutilized regions such as Eastern Europe, and refining source-separated collection methods to mitigate contamination, are emphasized. The potential benefits of automated sorting systems is underscored, notwithstanding the economic threshold faced by smaller facilities. The study reveals the challenges of recycling complex packaging materials and underlines the necessity to eliminate mineral oil hydrocarbons from printing inks or to employ functional barriers for reutilizing recycled paper fibres in food packaging. Public awareness and consumer behaviour are identified as vital enablers for recycling efforts. Furthermore, the need for industry cooperation, adherence to guidelines, and designing for recyclability emerge as crucial for reaching recycling objectives. This research suggests that overcoming these challenges and leveraging identified enablers can aid policymakers and stakeholders in establishing a circular economy via enhanced paper recycling efforts.

Keywords: recycling, waste management, paper recycling, circular economy, waste paper, fibre-based recycling, fibre-based packaging, paper recovery.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
4EG	4evergreen
ACE	Alliance for Beverage Cartons and the Environment
Al	Aluminium
CE	Circular Economy
CEPI	Confederation of European Paper Industries
CO2eq	Carbon Dioxide Equivalent
EPRC	European Paper Recycling Council
EN	European Norm
FSC	Forest Stewardship Council
LCA	Life Cycle Assessment
MOH	Mineral Oil Hydrocarbons
NIR	Near-Infrared
PE	Polyethylene
PET	Polyethylene Terephthalate
PfR	Paper for Recycling
RCP	Recovered Paper
VIS	Visual Imaging Sensors
WtE	Waste-to-Energy

INTRODUCTION

The transition to a Circular Economy (CE) necessitates the elimination of linear production processes and the throwaway attitude, resulting in an increased emphasis on reusing and recycling waste materials (Maitre-Ekern, 2021). The public's demand for a reduction in raw material consumption has surged, leading to an increased demand for used paper fibres in associated industries (Virtanen and Nilsson, 2013). Over the past decades, the demand for recovered paper has witnessed significant growth. At the European level, the utilization of recovered paper has doubled from 25.70 million tons in 1991 to 48.00 million tons in 2020 (CEPI, 2013b, 2022) Furthermore, paper recycling plays a crucial role in minimizing the environmental impact, as recycled fibres hold significant value as raw materials for the production of paper and paperboard (Adu, Jolly and Thakur, 2018). With the ability of paper fibres to retain 70% to 90% of their original strength even after undergoing five recycling cycles and the potential for reinforcement through the use of swelling agents or surface additives, there is a feasible opportunity for enhancing the recycling rate (Nazhad, 2005; Campano et al., 2018).

The European paper value chain has been dedicated to the improvement of paper recycling since the beginning of the millennium, delivering efforts to overcome barriers that impede paper recycling. These efforts have led to remarkable progress in paper recycling within Europe, as evidenced by the attainment of an alleged recycling rate of 73.9% for all paper and board in 2020, nearly fulfilling the target of 74% set for the same year (EPRC, 2022). The historical development of the collection rate of paper for recycling (PfR) indicates a positive trend, considering that in 2010, the collection rate stood at 66.8%, which is equivalent to the collection of 57.14 million tons of recovered paper for recycling. The average collection rate has experienced a substantial increase in recent years, rising from 41% in 1991 to 67% in 2010, and reaching 73% in 2020 (CEPI, 2022). Nevertheless, notable disparities among countries exist, with some nations such as Germany, The Netherlands, and Norway approaching rates between 75% and 90%, while Eastern European countries seem to be lagging (Eurostat, 2023).

Despite the steady growth of the recycling industry for paper in Europe, the recycling target of 85% for fibre-based packaging in 2030, set by the European Parliament and Council (EPRC) (2022), has yet to be achieved. In line with the European Union's ambitions, 4evergreen (4EG), a cross-industry alliance of over 100 members representing the entire lifecycle of fibre-based packaging, aims to achieve a recycling rate of 90% for fibre-based

packaging by 2030 (4evergreen, 2020). The alliance intends to foster knowledge exchange among its members to develop tools, guidelines, and protocols for standardizing recycling methods, design principles, and collection and sorting methods, to advance the sustainability of the sector (4evergreen, 2022).

Consequently, a significant untapped potential for the recovery of used paper in Europe remains, this research seeks to explore the barriers and key enablers that influence the attainment of the 90% recycling target for fibre-based packaging in Europe. More explicitly, this study aims to identify the factors that are related to catalysing or hindering higher percentages of cellulose fibre recycling in the packaging industry and propose practical strategies and solutions to be adopted by industry stakeholders. Additionally, the research aims to provide insights into the effectiveness of existing practices and policies related to fibre-based packaging recycling in Europe and contribute to ongoing efforts in building a more sustainable and circular paper value chain in Europe. Thus, the research question is formulated as follows:

> ***What are the barriers and key enablers of reaching the fibre-based packaging recycling target of 90% in Europe?***

THEORY

Recycling Infrastructure

Collection Systems

The collection of paper for recycling (PfR) marks the initial stage of the recycling process and has been recognized as crucial for expanding the scope of paper recycling (Miranda et al., 2010). Firstly, Blanco, Miranda and Monte (2013) conclude that an untapped potential for expanding the collection of PfR remains, particularly in Eastern Europe. (Malinauskaite *et al.*, 2017), which are often commingled, or single-stream, waste collection. These findings remain consistent with the most recent statistics reported by Eurostat (2023). However, further studies into the paper collection systems of Eastern European countries are lacking. Statistical data indicates that European paper mills can obtain a higher supply of PfR by focusing on increasing and enhancing household collection methods as other sources are already almost fully utilized (Iosip et al., 2014). In accordance with Iosip et al. (2014), the findings of Blanco, Miranda and Monte (2013) indicate that it is paramount to enhance the availability of recovered paper through the implementation of efficient selective collection systems.

The selection of appropriate collection methods is not only significant for achieving a higher quantity of recovered paper but also in order to ensure its quality and composition. It is widely acknowledged that expanding collection efforts from households can have a negative effect on the quality of the recovered paper (Miranda *et al.*, 2010; Miranda, Concepcion Monte and Blanco, 2011). The subpar quality of the recovered paper is primarily attributed to the presence of non-paper components and undesirable paper and board materials, which render them unsuitable for use. Contamination issues predominantly arise due to commingled collection systems, which are favoured by certain municipalities due to their cost-effectiveness compared to source-separated collection methods (Miranda, Monte and Blanco, 2013). Studies have shown that making system changes, such as adopting a source-separated collection method for recyclable materials, can have a significant positive impact on material recovery (Miranda, Monte and Blanco, 2013; Gundupalli, Hait and Thakur, 2017). According to the findings of Malinauskaite *et al.* (2017) not only does this approach result in higher rates of material recycling, but it also leads to substantial reductions in global warming potential and cumulative energy demand compared to a waste-to-energy (WtE) based system.

Finally, it is important to note that an inherent constraint on the recovery of paper exists, stemming from a portion of papers that cannot be collected or recycled (Miranda *et al.*, 2010). These papers fall into the category of non-collectable or non-recyclable products due to either technical limitations or their utilization in permanent applications. Examples of such products include cigarette paper, tissue paper, wallpapers and archives. It is important to acknowledge that these specific papers cannot be included in the paper recovery process due to their unique characteristics or intended purposes.

Sorting Systems

In accordance with the above, the EPRC (2022) considers source-separated collection systems for paper and board as the most efficacious approach for enhancing the circularity of these products and maximizing their potential for recyclability. Additionally, the CEPI proposes a two-bin system for discarding fibre-based packaging material, further separating paper-based materials from composite materials, such as beverage cartons (EPRC, 2022). In March 2021, the members of the Alliance for Beverage Cartons and the Environment (ACE) adopted their 2030 Roadmap, which sets ambitious targets of collecting 90% of beverage cartons and recycling a minimum of 70% of beverage cartons by 2030. In countries with inadequate collection rates, the implementation of a deposit return scheme that includes all beverage cartons is proposed. Sorting offers several key advantages regardless of its location (Bobu, Iosip and Ciolacu, 2010; Miranda *et al.*, 2010). Firstly, it reduces the presence of unwanted components in the recovered paper, resulting in a cleaner and more homogeneous raw material. This improves the quality of the recovered paper and enhances its suitability for reuse in paper and board products. Additionally, sorting enables the production of customized grades of recovered paper, tailored to meet specific requirements, thereby optimizing its reuse potential (CEPI, 2013a). The European Union (EU) has implemented the EN 643 standard to differentiate the various grades, “EN” stands for “European Norm” and “643” is the numerical identifier assigned to the specific standard for paper and board waste classification. Although technological advancements have been made, the sorting of recovered paper in Europe still predominantly relies on manual labour (Bobu, Iosip and Ciolacu, 2010). The process involves an inclined conveyor and a speed-adjustable sorting belt, which presents several major challenges. Firstly, it is a labour-intensive process, which incurs relatively high processing costs and results in inconsistent quality of end products due to human error (Rahman *et al.*, 2009). Moreover, manual sorting is associated with several health risks,

laborers working at manual sorting facilities are repeatedly exposed to microorganisms, organic dust, and fungi, which may cause infection and illness (Würtz and Breum, 1997).

However, there is a growing trend towards automation, which helps to reduce sorting costs and effectiveness (Rahman, Hussain and Basri, 2014). Automated sorting technologies combine imaging methods, including near-infrared (NIR) spectroscopy and visual imaging sensors (VIS), to provide a high level of accuracy in material recognition and sorting. By analyzing the optical properties of materials, such as composition, colour, and spectral characteristics, these systems can accurately identify and separate different types of materials (Ferrari, Mottola and Quaresima, 2004). This enables efficient recovery of valuable resources from waste streams and contributes to maximizing material recovery rates, reducing rejects and waste (Bobu, Iosip and Ciolacu, 2010). Despite the benefits, there are still challenges to overcome. For instance, the application of optical systems, particularly NIR technology, can involve significant upfront investment and operational costs, as well as specialized knowledge (Rahman *et al.*, 2009). The initial cost factor and learning curve may pose a challenge for smaller recycling facilities or regions with limited financial resources.

Recyclability of Paper Products

Building on the aforementioned, the attention to product management at the end of its life cycle, along with the incorporation of design features for enhanced recyclability, are critical elements influencing the recyclability potential of paper-based products (Cai and Choi, 2019). The deinking process occupies a crucial role in the fabrication of packaging materials, particularly due to the demand for specific optical properties of the final products (Blanco, Miranda and Monte, 2013). The predominant technology employed for deinking across Europe is flotation, in which fine air bubbles are introduced into the suspension to carry ink particles to the surface, where they can be effectively separated from the pulp (Venditti, 2004; Faul, 2010). The efficiency of this procedure is contingent on the ink exhibiting particular properties, such as hydrophobicity and a definite particle size range (Faul, 2010). The flotation process, which is commonly used for de-inking, may not be efficient for removing flexographic and inkjet ink particles due to their hydrophilic nature and small size. Additionally, cured systems and certain toners, especially liquid toners, tend to form agglomerates that are too large to float effectively

Composite packaging materials, exemplified by cartons intended for liquid containment, present a more formidable challenge to recycling efforts owing to their complex

stratified structure composed of paper, polyethylene (PE), and aluminium (Al) layers (Zawadiak, 2017). This type of packaging material typically has a composition of approximately 70% cardboard as the primary component, along with 25% PE and 5% Al (Haydary, Susa and Dudáš, 2013). This complexity often results in a substantial fraction of these materials being rejected and ending up either incinerated or in landfills (Agamuthu and Visvanathan, 2014). However, contrary to common assumptions, the multilayered 'aseptic beverage cartons' are not impossible to recycle (Robertson, 2021). Several methods, including hydra pulping, thermal processes, and chemical approaches, offer the potential for the extraction and reuse of paper fibres, either for the remanufacturing of paper-based packaging or for the creation of construction materials (Lopes and Felisberti, 2006; Prawisudha *et al.*, 2014). In accordance with the findings of Bobu, Iosip and Ciolacu (2010), a selective sorting and recycling of multilayer packaging is considered necessary in order to increase recycling efficiency (Kaiser, Schmid and Schlummer, 2017). Nevertheless, the effective industrial-scale separation of the remaining PE and Al remains an unsolved challenge, due to the requirement of additional recycling methods, high energy expenditure and subsequent lack of economic attractiveness (Muñoz-Batista *et al.*, 2022; Baltacı *et al.*, 2023).

In response to concerns regarding the sustainability of plastic packaging and its environmental impacts, large companies have begun to substitute plastic with fibre-based solutions (‘Frosta to Switch to Paper Packaging from 2020’, 2019; *Nestlé launches YES! snack bars in recyclable paper wrapper*, 2019; *Packing Ritter Sport in paper*, 2020). Fibre materials derived from cellulose offer favourable end-of-life properties as they are often recyclable and supported by established recycling infrastructure in many countries. Nevertheless, it is important to acknowledge that the utilization of mechanically recycled fibre materials in direct food contact applications is constrained due to the possibility of cross-contamination and safety considerations (Biedermann, Uematsu and Grob, 2011). The ‘virgin’ materials are sourced from certified providers in Europe, recognisable by the FSC certification, ensuring responsible procurement without contributing to deforestation or ecosystem degradation (FSC, 2018). Moreover, cellulosic fibre materials are well-regarded by consumers, facilitating effective sustainability communication and garnering interest from supply chain stakeholders, including brand owners, retailers, and consumers. A life cycle assessment (LCA) by Schenker *et al.* (2021), comparing fibre-based solutions to their fossil-based counterparts, confirms that cellulose fibre-based materials exhibit lower environmental impacts when achieving similar packaging weights. Polymer-based materials

have impacts ranging from 3 to 5 kg CO2eq/kg, while cellulosic fibre-based materials have impacts below 1.5 kg CO2eq/kg. However, due to health hazards, the presence of mineral oil hydrocarbons (MOH) in PfR poses a risk to the suitability of recycled fibre-based paperboard for food packaging (Grob, 2018; Koster *et al.*, 2020). To enable the utilisation of recycled paper fibres in food packaging without the need for polymer-based barriers, the complete elimination of MOH from offset printing inks is required, including those used in various printed materials and not just newspapers (Biedermann, Uematsu and Grob, 2011). Alternatively, one possible solution is to incorporate a functional barrier within the packaging, such as an internal bag made of materials like aluminium or PET, which effectively slows down or prevents the migration of MOH (Biedermann *et al.*, 2013; Biedermann-Brem, Biedermann and Grob, 2016).

Public Awareness

Environmental awareness plays a significant role in enhancing the collection of Paper for Recycling (PfR), as highlighted by Miranda Carreño et al. (2010). Existing research findings consistently support the notion that individuals are inclined to participate in recycling endeavours primarily due to their perception of recycling as an essential means of attaining environmental objectives (Hornik, Cherian and Madansky, 1995; Geiger *et al.*, 2019). When individuals possess a higher level of environmental awareness, they are able to exert influence on municipal bodies and other institutions, advocating for recycling promotion and the enhancement of collection resources. Furthermore, as a result of consumer pressure and regulatory demands, the printing and converting industries may become compelled to increase their production of recyclable paper products (Zhang and Zhu, 2019). To achieve this, it becomes imperative to integrate eco-design criteria into the manufacturing process, such as environmentally friendly printing inks, coatings, adhesives, and related materials (Mayers, 2007; 4evergreen, 2022). By incorporating such criteria, these industries can align their practices with sustainability objectives and contribute to the overall improvement of paper recycling efforts. Additionally, consumer awareness about environmental consequences leads to reduced sorting costs in waste management and improves the quantity and quality of collected materials through source separation (Debrah, Vidal and Dinis, 2021).

Gap Identification

While the literature provides significant insights into various aspects of paper recycling, it reveals several gaps in our understanding of achieving a 90% recycling rate target for fibre- based packaging. Firstly, there is a lack of comprehensive research regarding the proficient recycling of food packaging at an industrial scale, particularly composite packaging materials and the implications of their contents. Although some techniques are already in use, the economic feasibility of these methods, given their high energy consumption and the necessity for additional recycling processes, remains inadequately examined. Furthermore, although automation in sorting systems is on the rise, research is scant regarding how smaller recycling facilities or regions with limited financial resources can overcome the initial cost and learning curve associated with the application of such technologies.

In addition, the literature overlooks the need for the complete elimination of mineral oil hydrocarbons (MOH) from offset printing inks, which poses a risk to the suitability of recycled fibre-based paperboard for food packaging. While the solution of incorporating a functional barrier within the packaging is suggested, it needs further exploration to determine its effectiveness, feasibility, and potential trade-offs. Finally, the role of public awareness and its influence on institutions and industries in promoting recycling and enhancing collection rates is under-explored. There is a gap in understanding how to effectively harness this influence to improve recycling rates and the quality of recovered paper.

Conceptual Framework

An efficient recycling infrastructure, sub-categorized in collection and sorting systems, is essential for achieving higher recycling rates in fibre-based packaging. While an effective infrastructure is an enabler, the expansion of collection systems with single-source collection can be a barrier due to the potential quality degradation of recovered paper. The right collection method, such as source separation, acts as an enabler by improving material quality and recycling rates. Automated sorting systems, despite being costly and requiring expertise, enhance material recovery efficiency, serving as an enabler.

The recyclability of paper products is another crucial aspect. Product designs favouring recyclability facilitate the process, while complex packaging materials, such as stratified composites, pose challenges, acting as a barrier. The shift towards fibre-based food packaging can enable a higher recovery of raw materials due to fibre's recyclability. However,

safety concerns and potential cross-contamination risks form a barrier for mechanically recycled fibre in food packaging.

Lastly, public awareness is a key enabler. It can bolster the collection of recyclable materials, pressure industries to produce recyclable products and incorporate eco-design criteria. However, the lack of it can act as a barrier. The identified barriers and enablers, which are derived from the existing literature are simplified and visually presented in the conceptual framework below:

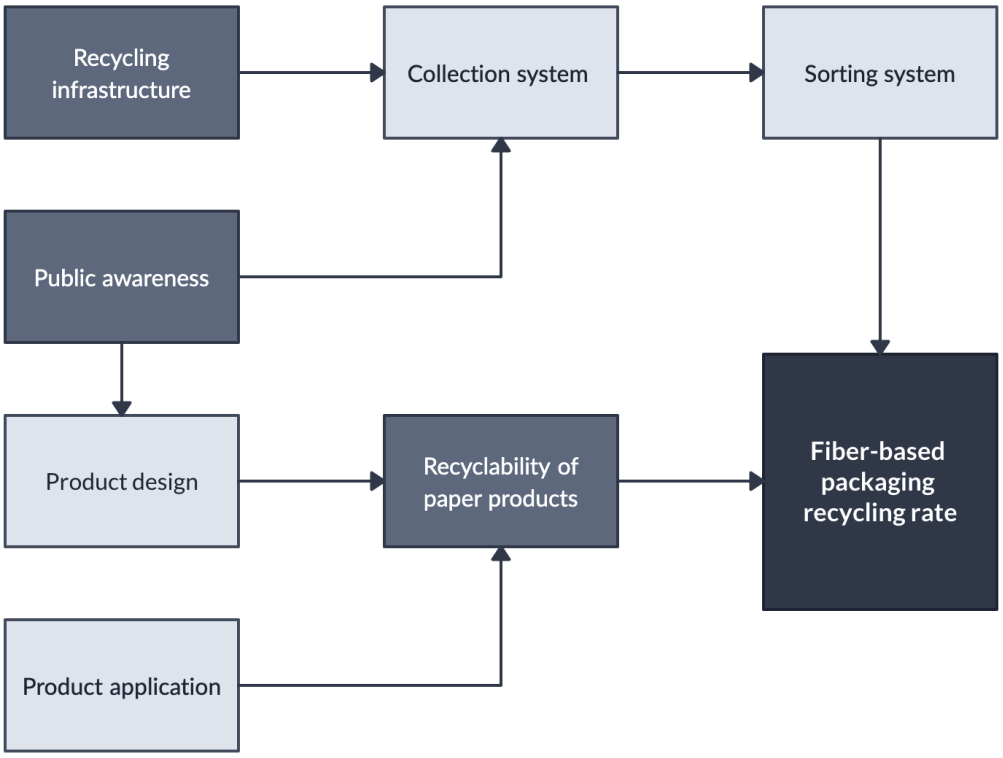

Figure 1 *- Barriers and enablers for achieving higher recycling rates of fibre-based packaging: a conceptual framework*

METHODOLOGY

This research aims to identify the barriers and key enablers of achieving a 90% recycling rate target for fibre-based packaging in Europe by using the grounded theory approach, which is an inductive method of research that allows the development of a theory based on the data gathered from the participants (Chun Tie, Birks and Francis, 2019). Grounded theory is a systematic approach that involves the continuous collection and comparison of empirical findings and the identification of patterns and categories that emerge from the data (Oktay, 2012). Therefore grounded theory is a qualitative research method that enables the derivation of new theories and concepts based on the iterative collection and analysis of real-world data (Corbin and Strauss, 2008). Prior to data collection and analysis, an explorative literature review has been conducted in order to gain a comprehensive understanding of the existing knowledge and research gaps, from which a conceptual framework was derived (Mitchell, 2014). By reviewing relevant literature, previously explored key concepts, theories and variables can be identified (Ramalho *et al.*, 2015). This knowledge allows for refinement of the research question and research design, ensuring that the study is relevant, innovative, and contributes to the existing body of knowledge. Moreover, a literature review provides a broader context for interpreting the results, helping the researcher understand the implications and significance of their findings in relation to existing knowledge (Hickey, 1997). The following section outlines the various stages of the research process.

Participants

The participants for this study are industry experts who are involved in the paper and fibre-based packaging industry in Europe. The sampling method was purposive sampling, which is a non-probability sampling method that allows for the selection of participants who are most relevant to the research topic (Palinkas *et al.*, 2015). Participants are selected based on their expertise and experience in the paper and fibre-based packaging industry, with a focus on individuals who have knowledge of the recycling process and the policies and regulations surrounding it. The following individuals from the case company were interviewed for data collection: Procurement Director Europe, Managing Director Graphical Mills, Chief Growth Officer, Head of Sustainability, Product Development Manager, Specialist Management Systems and Food Safety, Sales Director Central Europe, Senior Procurement and Waste Management.

Data Collection

The data collection process is called theoretical sampling and is collected through qualitative interviews with the participants. Theoretical sampling involves purposefully selecting participants and collecting data based on emerging theoretical insights, allowing for the development and refinement of the theory as the research progresses (Corbin and Strauss, 2008). To gather the necessary data, semi-structured interviews are conducted with the participants. Semi-structured interviews are a flexible method of data collection that enables the exploration of the research topic in depth (Palinkas *et al.*, 2015). This approach allows for a balance between a pre-determined set of questions and the freedom for participants to elaborate on their experiences and provide rich, contextual information.

The interviews were conducted either in person or through video conferencing, depending on the preference and availability of the participants. This flexibility ensured that participants could choose the mode of communication that was most convenient for them, thus maximizing participation rates and accommodating individual preferences and logistical constraints. However, video conferencing for qualitative research interviews is not without drawbacks (Sedgwick and Spiers, 2009). Technical issues such as poor internet connection, audio/video glitches, and software malfunctions can disrupt the interview flow. Additionally, the absence of a controlled research environment during video conferencing interviews makes participants more susceptible to distractions and multitasking, compromising the depth and quality of their responses. Moreover, the impersonal and distant atmosphere created by video conferencing can hinder the establishment of a strong rapport and trust between the researcher and participant, thus impacting the participant's willingness to openly share personal experiences and insights. During the interviews, audio recordings were made to capture the participants' responses accurately. The use of recording devices enabled the researchers to focus fully on the interview and avoid missing valuable information (Berazneva, 2014). Following the interviews, the audio recordings were transcribed verbatim to create a textual representation of the data. The transcriptions were carefully reviewed and analyzed to identify patterns, categories, and themes. This process involved repeated readings and coding of the data to extract meaningful concepts and develop a grounded theory.

Data Analysis

The data collected from the interviews was analysed using the grounded theory approach as described above. The analysis involved coding the data, identifying categories, and developing a conceptual framework that elaborates on the barriers and key enablers of achieving a 90% recycling rate for fibre based packaging in Europe. The coding process initiated with open coding, where the data was broken down into smaller segments and given a label that describes the content of the segment (Chun Tie, Birks and Francis, 2019). Axial coding was then used to identify relationships between the codes and finally, the core category was found using selective coding. The core category ultimately connects all codes together and forms the basis of the theory. The iterative nature of grounded theory research enables the researcher to continuously compare new data with the existing codes and categories, ensuring theoretical saturation is reached, and the theory is robust (Burnard, 2006).

Constant comparison (Leech and Onwuegbuzie, 2011; Chun Tie, Birks and Francis, 2019), another fundamental principle of grounded theory, was employed. The constant comparison process involves continuously comparing new data with the existing codes and categories to refine and validate the emerging theories, identify variations and similarities, and ensure the analysis remains grounded in the data (Corbin & Strauss, 2008).

Overall, the data analysis process involved an in-depth examination of the interview data through open coding, axial coding, constant comparison, and selective coding, resulting in the development of a grounded theory. The final stage of the data analysis process involved the integration of the identified categories and themes into a coherent coding tree, which presents the barriers and key enablers of achieving a 90% recycling rate target for fibre based packaging in Europe, based on the patterns, relationships, and insights derived from the data.

Consideration of Research Ethics

The researcher has the responsibility of adhering to certain ethical guidelines in a qualitative study (Mohd Arifin, 2018). The following ethical considerations have been addressed to safeguard participant rights, privacy, and confidentiality:

1. **Privacy:** Participants' privacy is of utmost importance. To protect their personal information, all identifying details are kept confidential. The researcher will ensure that access to participant data is restricted to authorized personnel only.

2. **Informed Consent:** Prior to conducting interviews and recording audio, explicit informed consent was obtained from all participants (see Appendix A). Participants were provided with detailed information about the research objectives, procedures, and the purpose of the audio recording (Munhall, 1988). Participants had the opportunity to ask questions and clarify any concerns before giving their consent.
3. **Data Security:** Stringent measures were implemented to ensure the security of audio recordings by exclusively using password-protected devices and encrypted offline storage systems to prevent unauthorized access or data breaches.
4. **Anonymity:** To minimize the risk of identifying individual participants, measures were taken to anonymize the audio recordings. All identifying information is removed or replaced with case numbers during the transcription and analysis process.
5. **Data Retention:** The duration for which the audio recordings will be stored is determined to be ten years. Protocols for the deletion of the recordings after the specified period are implemented, ensuring that participant data is not retained beyond the necessary timeframe.
6. **Researcher Conduct:** The researcher adhered to professional ethical guidelines and used the audio recordings solely for the intended research purposes. Audio recordings were handled with care, maintaining confidentiality and respecting participant privacy.
7. **Institutional Review:** The research protocol, including the use of audio recordings, was subjected to an ethical review process. Approval from the ethics committee of the University of Groningen has been provided, demonstrating compliance with ethical standards and guidelines (see Appendix B).

RESULTS

Through the analysis of interview data, four central themes emerged in the form of “Recycling Infrastructure, Contamination of Recovered Paper, Design and Recyclability of Paper Products and Public Awareness and Consumer Behaviour”, which are elaborated in detail under the respective headings. By employing a process of open, axial and selective coding, an intricate coding tree was composed that provides a comprehensive overview of the various elements influencing the attainment of fibre-based packaging recycling targets in Europe, which is presented in Figure 2.

Recycling Infrastructure uncovers various issues related to collection systems, sorting methods, and the intricacies of separating recyclable materials. It also reveals different perspectives on waste collection methods, with mentions of better source separation, centralized sorting, more advanced technologies and the variability of recycling infrastructure across different markets.

The second key theme, "Contamination of Recovered Paper" delves into the serious implications of contamination in the recycling process. Through these discussions, participants express concerns about the types and impact of contamination.

The third theme, "Design and Recyclability of Paper Products" delves into how product design can influence the recyclability of paper products. The conversations highlight the importance of design choices, the development of plastic-free solutions, harmonization of packaging design guidelines, and the difficulty of recycling certain composite materials.

The final theme, "Public Awareness and Consumer Behavior" underscores the critical role of consumers in achieving recycling targets, covering the importance of public awareness, the need for clear guidance on waste separation, and the impact of consumer behavior on recycling efforts.

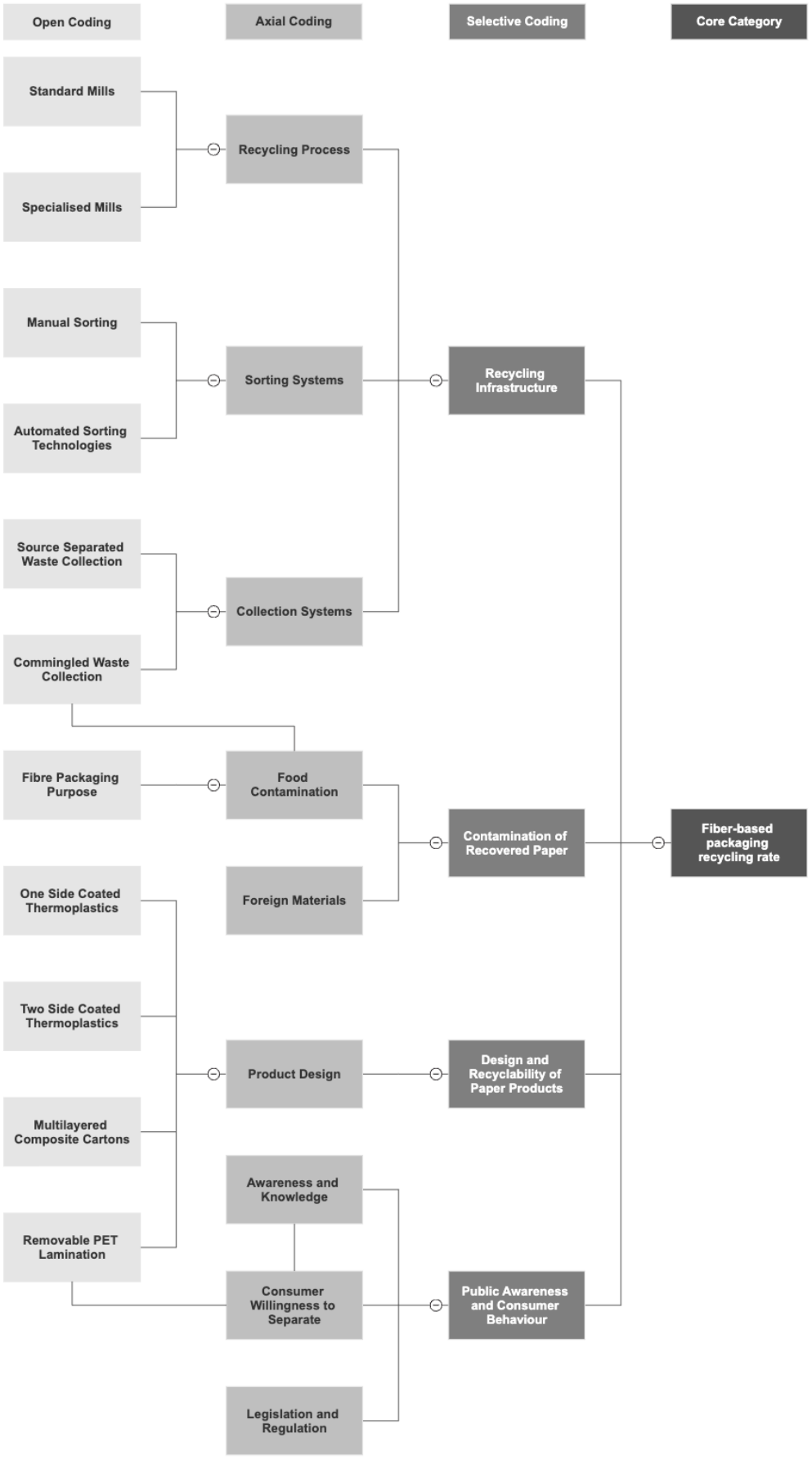

Figure 2 *- Coding tree for qualitative analysis*

Recycling Infrastructure

The qualitative interviews revealed key findings regarding collection and sorting systems as barriers and enablers of reaching the 90% fibre-based packaging recycling target in Europe. Municipal collection systems were mentioned as significant sources of recovered paper (Interviewee A, 2023). However, the participants repeatedly mentioned contamination as a concern and emphasized the need for improved sorting methods, with centralized sorting methods being suggested as a potential solution. Technological advancements in sorting technology were considered as positive factors, but challenges in separating recyclable materials from non-recyclable ones are also highlighted. The composition of municipal waste, particularly from domestic households, was perceived as a hindrance to achieving the recycling target due to the presence of foreign materials and contamination. The proximity and accessibility of collection systems, along with the availability and accessibility of waste sorting services, were perceived as enabling factors.

Interviewee B (2023) emphasized the need for municipalities to rethink waste collection methods and improve collection systems. Differentiated rates for waste and consumer behaviour were noted, influencing waste collection practices:

> B: *"If you have a paper one and a household one and they put waste into the paper one. If it is spoiled, we will reject it and we reject from certain areas in the city of Groningen, we do not want their paper streams, because people put things in the recovered paper which should not be there and then it's not fit for use anymore."*

The choice between source separation and commingled systems was discussed and Interviewee C (2023) mentioned that source separation was considered beneficial for avoiding food contamination. The importance of industry collaboration, data-based systems, and standardized regulations across the EU was emphasized.

Another participant mentioned insufficient sorting infrastructure and the variability of recycling infrastructure across different markets as barriers (Interviewee D, 2023). Challenges in accurately calculating the recycling rate were also mentioned, with the mention of whether or not industry members should differentiate between RCP (recovered paper) and new products manufactured.

Interviewee E (2023) highlighted the benefits of mixed paper grades in recycling, noting a lower reject rate and higher yield. Variations in pulping capabilities and rejection rates between regions were recognized as challenges. Further separation at the recycling

location was proposed as a solution, directing recyclable fibre packaging to normal mills and difficult to recycle composites to specialized mills:

> E: *"Use our collection system to collect what is present on the market and what we can obtain, separate it into material which is well usable in our normal mills and send the other junk to specialized mills but at a price that we control better."*

Interviewee F (2023) identified challenges related to waste procurement, adherence to legislation, and the gap between written practices and implementation. Exploring alternative fibres, such as tomato stems, was suggested but is currently not implemented due to the absence of FSC certification.

Interviewee H (2023) highlighted the importance of government control to ensure cleaner paper fibre streams. Challenges in waste separation and handling, including the complexity of separation, reliance on manual practices, limited automation, and doubts about the true separation and recycling of mixed waste, were raised:

> H: *"There are some companies or mills that can do it, but I think most of it, they are not able to fully separate it."*

Contamination of Recovered Paper

The qualitative interviews revealed that the contamination of recovered paper emerged as a significant barrier to achieving the fibre-based packaging recycling target of 90% in Europe. Participants expressed concerns about various types of contamination and their impact on the recycling process, thereby hindering the attainment of high recovery rates. The findings from each interview shed light on different aspects of this issue.

One participant highlighted the limitation of the EN 643 paper grade, explaining that materials not conforming to the standard, such as items with food contact, were considered contaminated and unfit for the recycling process (Interviewee A, 2023):

> A: *"Because you do see a lot of the single plastics are being replaced by paper fibre based packaging solutions. I don't think a lot of those products, according to the current regulations, are allowed to be put into our process to reuse those fibres."*

The participant also questioned whether materials in contact with food could be recycled, further emphasizing the concern of contamination. The presence of foreign materials in paper

waste was mentioned as a challenge, indicating the need for better separation methods. To address this issue, participants suggested the possibility of washing off contaminants and improving sorting at the source.

Interviewee B (2023) emphasized the importance of sorting and contamination management. They highlighted the negative impact of contamination on the recovery rate, indicating that failure to address this issue would hinder the achievement of the 90% target. Adherence to regulations, particularly EN 643, and the establishment of separate waste streams were stressed as crucial factors. The presence of unwanted items, including diapers, in the recovered paper, was also mentioned as a contamination concern.

In contrast to the other participants, Interviewee C (2023) expressed confidence in the recycling processes' ability to handle contamination effectively, including food residues:

> C: *"I think our processes should be robust enough to handle these mixed streams that include plastics and even pieces of food, pieces of pizza, or whatever else you have."*

However, concerns were raised about the potential smell caused by certain heavily contaminated paper streams, which could compromise the desirability of the paper fibres. Interviewee E (2023) emphasized the significance of contamination in fibre-based packaging recycling. Participants highlighted the need to remove contaminants such as tapes, staples, sand, polystyrene, and microplastics to ensure high-quality output (Interviewee E, 2023; Interviewee B, 2023). The presence of food residue in recycled paper products was not preferred due to concerns about attracting insects, rodents, and unpleasant odours (Interviewee E, 2023). The participant indicated the need for proper preparation and separation at the source to address contamination issues effectively.

Interviewee F (2023) highlighted the risks of direct food contact with recycled fibres, due to the migration of mineral oil hydrocarbons (MOH):

> F: *"This substance may migrate, so from the packaging material into the food… and then when the consumer eats this meat for example, it's not good for their health."*

The presence of food remnants in pizza boxes and the potential contamination from meat trays posed challenges in recycling. Compliance with European and national legislation was identified as a key barrier. Balancing safety and recycling goals was a challenge, particularly in terms of meeting consumer health safety and legislative requirements, which

was also mentioned by interviewee H (2023). The unknown composition of recycled products allegedly further complicated the issue, expressing concerns about chemical contamination and the search for solutions to address health concerns (Interviewee F, 2023).

The specific requirements of the food industry were discussed, with interviewee H (2023) emphasizing the need for lining paper with proper food safety declarations. Contamination concerns with food packaging and the potential smell and hygiene issues associated with certain animal products were also mentioned. Different smells associated with recycled paper were noted, indicating the presence of contamination. Finally, the necessity for lamination with virgin lining paper and polymers in direct food contact was highlighted:

> H: *"We laminate virgin lining paper with a PE coating to protect actually what is inside… otherwise we cannot even be in those industries."*

Design and Recyclability of Paper Products

Another significant barrier repeatedly mentioned by the participants was the role of product design and the recyclability of paper products in achieving recycling targets. Interviewee A (2023) highlighted that packaging design should facilitate easy separation to improve recycling rates while emphasizing the condition of consumer awareness and their willingness to participate in waste separation. Interviewee B (2023) emphasized that appropriate design choices can increase the recovery rate and improve recyclability with the concept of Modified Atmosphere Packaging (MAP), which is designed for easy removal of the plastic layer:

> B: *"It should be simple for our consumers or for us to to be able to separate. So MAP's are the way to go, because it basically reduces the plastic use in the packaging by 90% and we will be able to input that into the paper stream."*

Efforts to develop plastic-free solutions and optimize the recycling process in paper-based packaging were also discussed (Interviewee C, 2023). Challenges related to specific packaging types were addressed. For example, two-side laminated packaging was determined to be a packaging type that should not be recycled with the standard paper waste stream by the industry alliance 4evergreen, which the participant did not agree with. The exploration of air/water barrier solutions and collaboration with biomaterials start-ups were mentioned as strategies to potentially overcome these challenges. It was also noted that

designing packaging for full recyclability, using labels and certification to educate consumers, and engaging customers for a long-term perspective is crucial.

Lack of harmonization in packaging design guidelines was mentioned as a barrier by interviewee D (2023). Standardized design guidelines were advocated to overcome hindrances posed by non-recyclable packaging components:

> D: *"We still see quite a few packaging materials that have all these forementioned components, so harmonization of design guidelines are needed and associations like 4evergreen are working on that to provide design for circularity standards, protocols and methods."*

Engaging in discussions regarding recyclability tests was considered important for achieving the recycling target. Collaboration through associations and exploring alternative material solutions, such as replacing fossil-based coatings, were also seen as potential enablers.

Another barrier suggested was the difficulty of recycling composite materials, specifically aseptic beverage cartons, like Tetra-Pak (Interviewee C, 2023; Interviewee E, 2023). The process of recycling multi-layered composite materials in pulpers was described as partly a matter of chance and statistics while emphasizing that these types of packaging are rejected more often. Furthermore, challenges related to manual consumer actions, safety concerns, and chemical contamination were highlighted in the recycling of paper into food packaging (Interviewee F, 2023; Interviewee G, 2023). Potential solutions included the use of secondary liners and coatings to prevent the migration of substances.

Public Awareness and Consumer Behaviour

Public awareness and consumer behaviour were recurring themes during data collection in the context of achieving the target of 90% fibre-based packaging recycling in Europe.

Interviewee A (2023) highlighted the importance of consumer awareness and their willingness to participate in waste separation. The participant emphasized the significance of an individual's role in recycling and expressed a positive attitude towards waste separation. Insights on consumer behaviour and its impact on recycling efforts were further discussed with interviewee B (2023). The participant emphasized the importance of consumer awareness in determining recyclability, while specifically mentioning the need to assess whether products can be placed in the paper bin or if they should be thrown away due to food

contamination. Additionally, different product design solutions for recycling, exemplified by MAP's for meat, poultry, and fish products, were mentioned. The participant emphasized that the recycling of these alternative product designs for packaging could only occur efficiently if consumers showed awareness and willingness to manually separate the plastic and fibre components (Interviewee B, 2023).

Interviewee D (2023) emphasized the need for consumers to understand their role in recycling and claimed that consumer awareness is crucial for driving change by stating:

D: *"I think a lot comes with consumer awareness, as you said, you know the consumer has a choice to make it happen".*

Consumer involvement in plastic separation were also discussed with interviewee E (2023), the participant elaborated on the benefits of involving consumers in material separation, particularly in reducing plastic waste and carbon footprint. Educating consumers on proper separation practices was deemed essential to achieve these benefits. Interviewee F (2023) emphasized the vital role of consumer awareness in preventing contamination. However, there was a need for greater alignment between consumer actions and official guidelines. Participants recognized the importance of consumer awareness but acknowledged the existing limitations.

Interviewee G (2023) indicated that both the industry and consumers were lacking sufficient awareness of the sustainable qualities and recyclability of fibre-based packaging. The participant claimed that consumer convenience and disposal habits, especially in fast-food contexts, posed challenges to achieving high recycling rates, stating:

> G: *"They don't want to be bothered with having to bring back packaging... They throw it out of the car".*

Shifting consumer behaviour and improving awareness of the environmental impact of packaging waste were emphasized as crucial drivers for change.

Interviewee H (2023) professed that increasing consumer awareness of the impact of plastic waste and the need for collection and recycling can be considered a positive trend. However, the disgust factor and unwillingness of consumers to separate materials were mentioned as potential barriers, stating:

H: *"Some people may find it disgusting to separate the plastic layer from the meat packaging, which could deter them from doing it"*.

DISCUSSION

This section seeks to confront the empirical results with the theory, analyzing the similarities, discrepancies, and emergent findings in relation to the the barriers and key enablers of reaching the fibre-based packaging recycling target of 90% in Europe.

The empirical results align with the theory, emphasizing the importance of the recycling infrastructure in achieving the desired recycling target. Both the theory and empirical results highlight the role of municipal collection systems as significant sources of recovered paper (Blanco, Miranda and Monte, 2013; Iosip *et al.*, 2014). However, empirical results brought to light issues of contamination in these systems, stressing the need for improved sorting methods. This ties in with the theory's emphasis on efficient selective collection systems and the potential of automation in sorting systems (Miranda Carreño *et al.*, 2010; Miranda *et al.*, 2010).

The theory and empirical results further converge on the issue of contamination, particularly from commingled collection systems. Empirical results provided a detailed understanding of the various types of contamination and their impact on the recycling process, including foreign materials, food residues, and the migration of substances from packaging materials into food. This reinforces the theory's assertion about the quality and composition of recovered paper being a significant barrier to increasing recycling rates (Miranda, Concepcion Monte and Blanco, 2011).

The recyclability of paper products, specifically the difficulty of recycling composite materials, is a common theme in both the theory and empirical results. Separation and isolated processing of composite packaging materials, exemplified by Tetra-Pak’s, is identified as a necessity in order to increase recycling efficiency (Bobu, Iosip and Ciolacu, 2010). However, the empirical findings suggest that these packaging materials are unsuitable for recycling due to food contamination, the potential sanitization of these packaging materials could be explored in future studies. Packaging design, identified as critical in the empirical findings, corroborates the theoretical mention of integrating eco-design criteria in the manufacturing process (Cai and Choi, 2019). Modified Atmosphere Packaging (MAP) emerged as a promising development for reducing plastic use, improving recyclability and solving the migration of MOH’s in food packaging, an aspect that could be further explored in future research.

The empirical results affirm the theory's assertion about the role of public awareness in enhancing paper recycling. The empirical findings indicate that consumer behavior and

awareness are crucial in determining the recyclability and success of alternative product designs, suggesting the need for consumer education and increased awareness of environmental impacts. This aligns with the theoretical emphasis on individuals' environmental awareness influencing recycling promotion and collection resources (Zhang and Zhu, 2019). Furthermore, the empirical findings align with the notion that consumer awareness and willingness to separate may lead to improvement in the quantity and quality of recovered fibres (Miranda Carreño *et al.*, 2010; Debrah, Vidal and Dinis, 2021)

The study identified several gaps in the current literature that future research might address, including industrial-scale recycling of food packaging, economic feasibility of recycling methods, and potential for incorporating removable functional barriers in packaging. The empirical results also call attention to consumer convenience and disposal habits as additional areas of focus.

Due to the lack of a proper recycling infrastructure and utilization of commingled waste management, a substantial amount of unattained paper fibres remain. Partly due to these reasons, the reach of service of the case company is mainly limited to Western Europe. Therefore, the empirical findings did not confirm the potential for expanding the collection of PfR in this region, as is suggested by Blanco, Miranda and Monte (2013). The following countries in particular are of interest for further research in implementing paper collection streams, as the collection data is missing: Albania, Bulgaria, Greece, Montenegro, North Macedonia, Poland, Serbia, Switzerland and Turkey (Eurostat, 2023).

In summary, increasing the fibre-based packaging recycling target in Europe requires a multifaceted approach that involves enhancing recycling infrastructure, minimizing contamination, optimizing product design, and fostering public awareness and consumer participation. These findings serve as a stepping stone for devising practical strategies and policy recommendations that could help Europe move closer to its ambitious recycling target.

Limitations and Further Research

This research, while extensive, is not without its limitations. The study primarily relied on qualitative interviews, and the views expressed may not fully represent all stakeholders within the industry. Additionally, due to the rapidly evolving nature of the recycling industry, continuous research is necessary to remain updated with new challenges and opportunities that may arise.

Moreover, the study concentrated on Europe, so the findings may not be applicable in other contexts. Therefore, further research could consider investigating similar questions in different geographical settings. Also, the research focused exclusively on fibre-based packaging recycling, leaving room for studying other types of packaging materials.

Reflecting on the transdisciplinary setting, the research exposed how intertwined the problem is, with political, social, economic, environmental, and technological dimensions. This suggests that addressing such a complex problem calls for transdisciplinary solutions, incorporating inputs from a wide range of sectors and disciplines. The study underlines the potential of transdisciplinary research to yield holistic and impactful insights into complex, real-world problems like achieving recycling targets in the circular economy. However, future studies into specific dimensions, such as LCA's of product designs, automated sorting methods and sanitization of packaging materials intended for food consumption, are recommended in order to gain further insight into realising an increased recycling of fibre material.

CONCLUSION

This research has explored various aspects of paper recycling, including recycling infrastructure, contamination of recovered paper, recyclability of paper products, and public awareness. The findings have provided valuable insights into the challenges and opportunities in achieving higher recycling rates for fibre-based packaging.

The literature review highlighted the importance of expanding the collection of Paper for Recycling (PfR) and enhancing household collection methods, particularly in untapped regions like Eastern Europe. In accordance with the empirical results, the need to address contamination issues associated with commingled collection systems and promote source-separated collection methods for better material recovery rates was determined. Furthermore, the results emphasized the role of sorting methods in reducing unwanted components in recovered paper and the growing trend towards automation. However, it acknowledged the challenges faced by smaller recycling facilities in adopting automation technologies due to upfront costs and specialized knowledge.

The recyclability of paper products was identified as a crucial factor in achieving higher recycling rates. The research highlighted the challenges posed by complex packaging materials, such as stratified composites, and the need for selective sorting and recycling methods. The complete elimination of mineral oil hydrocarbons (MOH) from offset printing inks was identified as a minimal requirement for utilizing recycled paper fibres in food packaging. Alternatively, the incorporation of functional barriers was suggested as a potential solution. The results suggest that implementation of design for removable coating, such as Modified Atmosphere Packaging (MAP), may provide the solution for food contamination and recycling of used fibres for food contact materials while simultaneously reducing plastic use and carbon footprint.

Public awareness emerged as a key enabler in enhancing collection efforts and influencing industries to produce recyclable paper products. The results emphasized the importance of consumer awareness, effective communication, and alignment with sustainability objectives. However, it also highlighted the need for further research on harnessing public awareness to promote recycling effectively.

Based on the results, refining collection and sorting methods, addressing contamination issues, and ensuring industry cooperation and uniform regulations are crucial for achieving recycling targets. Public awareness, consumer behavior, and adherence to guidelines and regulations play a significant role in meeting recycling goals. Additionally, the

design and recyclability of paper products need to be optimized through easy separation of plastics, consumer involvement, standard design guidelines, and exploration of alternative materials.

In conclusion, this research provides important insights into the challenges and opportunities in achieving higher recycling rates for fibre-based packaging. It underscores the need for an efficient recycling infrastructure, product designs favoring recyclability, and public awareness. By addressing the identified challenges and leveraging the facilitators, policymakers and industry stakeholders can work towards a sustainable and circular economy with improved paper recycling efforts. This research serves as a stepping stone in the journey towards a more sustainable future, providing invaluable insights that could guide policy recommendations and practical strategies to drive Europe closer to its ambitious recycling target.

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APPENDIX A

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Barriers and Key Enablers of Achieving a Fibre-based Packaging Recycling Target of 90% in Europe.

Consent to take part in research

1. I, _____, voluntarily agree to participate in this research study.
2. I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences.
3. I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.
4. I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.
5. I understand that participation involves the conduction of a semi-structured interview.
6. I understand that I will not benefit directly from participating in this research.
7. I agree to my interview being audio-recorded.
8. I understand that all information I provide for this study will be confidential.
9. I understand that in any report on the results of this research, my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of the people I speak about.
10. I understand that disguised extracts from my interview may be quoted in the written report and conference presentation.
11. I understand that if I inform the researcher that I or someone else is at risk of harm they may have to report this to the relevant authorities - they will discuss this with me first but may be required to report with or without my permission.
12. I understand that signed consent forms and original audio recordings will be retained in possession of Rijksuniversiteit Groningen for a period of ten years after the interview date.
13. I understand that a transcript of my interview in which all identifying information has been removed will be retained for ten years after the interview date.

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14. I understand that under freedom of information legalisation, I am entitled to access the information I have provided at any time while it is in storage as specified above.

15. I understand that I am free to contact any people involved in the research to seek further clarification and information.

Soner Ortabozkoyun - MSc Sustainable Entrepreneurship
s.ortabozkoyun@student.rug.nl / obk.soner@gmail.com

Niels Faber - Academic Supervisor
n.faber@rug.nl

Signature of research participant

Signature of researcher

Date

APPENDIX B

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CF Research ethics checklist for BA-MSc student projects

February 2023

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This checklist is based on *Research Ethics for Students in the Social Sciences* (Jaap Bos, 2020), an open-access book that provides a non-technical introduction to research ethics and integrity-related issues.
The procedure for completing this checklist and submitting it to the Campus Fryslân Ethics Committee is as follows:

1. The student completes and signs the ethics checklist and sends it to the supervisor.
2. The supervisor reviews and countersigns the checklist.
3. The signed checklist is then sent by the supervisor to: ethics-cf@rug.nl.

Please do not hesitate to contact ethics-cf@rug.nl with any questions concerning the procedure.

1. Participants

- What is the (estimated) number of participants? What is the power analysis to determine sample size, if relevant?
  10
- Does the study involve participants who are unable to give informed consent (i.e. people with learning disabilities)? If yes: Explain why and what measures you will take to avoid or minimize harm.
  No
- Does the research involve potentially vulnerable groups (i.e. children, people with cognitive impairment, or those in dependent relationships)? If yes: Explain why and what measures you will take to avoid or minimize harm.
  No
- Will the study require the cooperation of a gatekeeper for initial access to the groups or individuals to be recruited? (i.e. students at school, members of self- help group, residents of nursing home)? If yes: Who is the gatekeeper? What agreement have you made, and which expectations do you share?
  No
- Will it be necessary for participants to take part in the study without their knowledge and consent at the time (i.e. covert observation of people in non-public places)? If yes: Explain why and how, and provide a risk analysis if applicable.
  No
- Will any dependent relationships exist between anyone involved in the recruitment pool of potential participants? If yes: Explain why and how, and provide a risk analysis.
  No

2. Research design and data collection

- Will the study involve the discussion of sensitive topics? (i.e. sexual activity, drug use, politics) if yes: Which topics will be discussed or investigated, and what risk is involved? What measures have you taken to minimize any risk, if applicable?
  No
- Are drugs, placebos, or other substances (i.e. food substances, vitamins) to be administered to the study participants? If yes: Explain the procedure and provide a brief cost-benefit analysis.
  No
- What measures have you taken to minimize any risk, if applicable?
  Non
- Will the study involve invasive, intrusive, or potentially harmful procedures of any kind? If yes: Explain the procedure and provide a brief cost-benefit analysis. What measures have you taken to minimize any risk, if applicable?
  No
- Could the study induce psychological stress, discomfort, anxiety, cause harm, or have negative consequences beyond the risks encountered in everyday life? If yes: Clarify the procedure and explain why no alternative method could be used. Provide a brief cost-benefit analysis if necessary. What measures have you taken to minimize any risk, if applicable?
  No
- Will the study involve prolonged or repetitive testing? If yes: Explain the procedure and clarify how the interests of the participants are safeguarded.
  No
- Is there any form of deception (misinformation about the goal of the study) involved? If yes: Explain the procedure and provide a rationale for its use.
  No
- Will you be using methods that allow visual and/or vocal identification of respondents? If so: What will you do to guarantee anonymity and confidentiality?
  Yes, vocal identification may be possible through audio recordings. Audio recordings are kept in offline storage in order to eliminate risk of data breach.

- Will you be collecting information through a third party? If yes: Who is that party? Provide a brief outline of the procedure.
  No
- Will the research involve respondents on the internet? If yes: How do you plan to anonymize the participants?
  No

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- How will you guarantee anonymity and confidentiality? Outline your procedure and give an estimate of the risk of a breach of confidentiality.
  The sole method of data collection is through audio recordings, the audio recordings will be kept in offline storage and labelled with numbers representing the interviewees in order to guarantee anonymity. Results will be presented without personal information and/or specific job descriptions that may identify the interviewees.
- What information in the informed consent will participants be given about the research? Please consult the template for information sheets and informed consent sheets for further guidance. Provide a brief summary or upload the consent form. Which procedures are in place in case participants wish to file a complaint?
  See consent form as appendix.
- Will financial compensation be offered to participants? Provide a short accounting of any compensation being offered.
  No
- If your research changes, how will consent be renegotiated?
  Sending an informative mail with a renewed consent form and the ability for interviewees to remove themselves and the recorded audio from the research.

3. Analysis and interpretation

- What is the expected outcome of your research? What would you consider a significant result?
  Identification of factors influencing the recycling rate of paper, a significant result would be the identification of practical implications for the industry.
- During the course of research, how will unforeseen or adverse events be managed (i.e., do you have procedures in place to deal with concerning disclosures from vulnerable participants)?
  Contact details of researcher and supervisor are provided in case of unforeseen or adverse events, research participants may choose to remove themselves from the research at any time.

4. Dissemination

- How do you plan to share your research findings? Which audience to you intend to target?
  Findings are shared through a written report and oral presentation, academics, policy makers and paper and board industry participants are target audiences.

5. Data storage

- Where will your data be stored? Which measures have you taken to make sure it is secure?
  Offline solid state storages.
- Which safety precautions have you arranged for in case of data leakage?
  Removing connectivity to the internet.
- Will your data be disposed of? If yes: When? (date) if no: Why not?
  Yes, ten years after the interview date.
- Will your research involve the sharing of data or confidential information beyond the initial consent given (such as with other parties)? What specific arrangement have you made and with whom?
  No

Supervisor – Niels Faber

Signed:  Date: **3-5-2023** Place: **Leeuwarden**

Student – Soner Ortabozkoyun

Signed:  Date: **3-5-2023** Place: **Leeuwarden**

APPENDIX C

Transcript - Interviewee A
Transcript - Interviewee B
Transcript - Interviewee C
Transcript - Interviewee D
Transcript - Interviewee E
Transcript - Interviewee F
Transcript - Interviewee G
Transcript - Interviewee H

Transcripts

APPENDIX D

Data Analysis

APPENDIX E

Signed Consent Forms