SUSTAINABILITY REPORTING AND PERFORMANCE: A COMPARATIVE STUDY OF LEADING PAPER AND PAPER-BASED PACKAGING COMPANIES

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Abstract. This research presents a comparative analysis of the sustainability performance of four prominent companies within the paper and paper-based packaging industry. Utilizing established sustainability indicators encompassing environmental, social, and economic dimensions, the study evaluated company performance based on publicly available data from their sustainability reports and disclosures. The findings revealed a diverse landscape of sustainability commitments and achievements, highlighting both shared industry-wide trends and company-specific approaches to sustainability management. All four companies demonstrated a strong commitment to waste management and circular economy principles, while also exhibiting varying degrees of progress in areas, such as renewable energy adoption, carbon emissions reductions, employee well-being, and social responsibility initiatives. The analysis further identified opportunities for improvement and highlighted the need for greater transparency, data disclosure, and industry collaboration to enhance overall sustainability performance and contribute to a more sustainable future for the paper and paper-based packaging sector. By examining the similarities and differences in the sustainability journeys of these four companies, this study provides valuable insights for industry stakeholders, policymakers, and researchers interested in promoting sustainable development within the paper and packaging industry and beyond.

Keywords: Economic sustainability, environmental performance, social responsibility, sustainability reporting, paper and paper-based packaging industry

INTRODUCTION

The amount of paper and paperboard a country uses is a reliable indicator of its development. Having access to paper is essential to our daily life, supporting communication, commerce, and countless aspects of modern society. As global demand for paper products continues to rise, the paper and packaging industry faces the critical challenge of ensuring a sustainable supply of raw materials (Pydimalla et al 2023). This challenge is further compounded by concerns regarding deforestation, high resource consumption, and waste generation associated with traditional paper production methods.

In response to these challenges, the industry is actively investigating alternative fiber sources and more sustainable production practices. This research paper focuses on a comparative analysis of the sustainability performance of four prominent companies within the paper and paper-based packaging industry. The companies considered were Duran Dogan, Kartonsan, Mondi Group, and Viking Kağıt.

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Duran Dogan: A leading Turkish packaging manufacturer specializing in cardboard and paperboard packaging solutions for a diverse range of industries, including food, cosmetics, and pharmaceuticals. The company places great emphasis on innovation and sustainability, as evidenced by its development of the "Gloss&Green" technology and its commitment to responsible sourcing and waste reduction.

Kartonsan: A prominent Turkish producer of coated cardboard, recognized for its high utilization of waste paper in production and its commitment to circular economy principles. The company operates a self-sufficient energy generation system and actively invests in environmental protection measures.

Mondi Group: A global leader in sustainable packaging and paper solutions, operating across the entire value chain, from responsible sourcing of raw materials to production and distribution of a wide range of packaging products. The company is known for its comprehensive sustainability strategy, including ambitious climate action goals and a strong focus on employee well-being and social responsibility.

Viking Kağıt: A leading Turkish tissue paper manufacturer, recognized for its pioneering Recyfiber® technology, which utilizes recycled beverage cartons to produce eco-friendly tissue paper products. The company demonstrates a strong commitment to sustainability, focusing on resource recovery, waste reduction, and responsible sourcing practices.

The sustainability strategies, initiatives, and performance data of the four companies across environmental, social, and economic dimensions were used, to provide insights into the diverse pathways toward sustainability within the sector and contribute to the ongoing discussion on responsible business practices in the paper and packaging industry.

The Size and Importance of the Global Paper Industry

Recent events, such as the Ukraine war and the COVID-19 pandemic, have demonstrated the significant impact that global disruptions can have on industries, including the paper and packaging sector. This can lead to challenges in the supply chain and shifts in consumer behavior (Vivas et al 2024). The global paper and paper-based packaging industry is a significant force, underpinning communication, commerce, and numerous aspects of modern life. In 2020 alone, the industry produced over 401 million tons of paper and paperboard, solidifying its position as the 15th largest industry globally (Deshwal et al 2019; Worku et al 2023). The industry's reach extends across four major submarkets: board and packaging paper, writing and printing paper, newsprint, and specialty papers (Deshwal et al 2019). Each of these submarkets caters to diverse needs and applications. Paper and paper-based packaging are ubiquitous, interwoven into the very fabric of our daily routines. They are used in the books we read and the documents we write, in the boxes that protect our goods, and in the tissues, used for hygiene.

The significance of the industry extends beyond its size. Paper remains a vital medium for information dissemination and cultural preservation, even in our increasingly digital world (Aithal and Shenoy 2016). Furthermore, paper-based packaging plays a critical role in the global supply chain, ensuring the safe and efficient transport of goods, while also offering sustainable and recyclable solutions compared with other packaging materials (Zhang and Sablani 2021; Le Quyen 2023).

However, the industry faces significant sustainability challenges. Deforestation, high resource consumption, and waste generation have led to concerns about the environmental footprint of the industry (Skene and Vinyard 2019; Vinyard 2021). Furthermore, the shift toward digital communication has the potential to threaten the availability of recovered paper, a key raw material for sustainable paper production (Ucelay 2020; Zambrano et al 2021). These challenges necessitate a transition toward more sustainable practices, including the use of alternative fiber sources such as agricultural waste and by-products (Baetge and Martin 2018; Otieno et al 2021), along with the

development of innovative recycling and waste management solutions (Méndez et al 2009).

In response to these challenges, the industry is investigating a range of potential avenues for enhancing its sustainability performance. The utilization of agro-based paper production, which employs agricultural residues in place of wood fibers, presents a promising avenue for addressing environmental concerns and facilitating accelerated growth (Jiang et al 2019; Neis et al 2019). Moreover, ongoing research into bio-derived materials, such as lignin and cellulose derived from agricultural waste, offers promising avenues for creating sustainable and functional packaging materials (Li et al 2012; Tajeddin 2014; Fadeyibi et al 2017; Shaghaleh et al 2018; Fitch-Vargas et al 2019; Travalini et al 2019; Karlovits 2020; Liyanage et al 2021; Nanda et al 2022).

By embracing innovation and adopting a more circular approach, the global paper and paper-based packaging industry can continue to fulfill its vital societal role while minimizing its environmental footprint and ensuring a sustainable future.

The Paper Industry: A Comprehensive Look at Its Environmental and Social Impacts

The paper and paper-based packaging industry, while essential to modern society, faces a complex interplay of environmental and social impacts. On the environmental front, concerns regarding resource consumption, and waste generation pose significant challenges (Skene and Vinyard 2019; Vinyard 2021). Additionally, the production process is resource-intensive, requiring substantial amounts of water and energy (Skene and Vinyard 2019; Vinyard and Skene 2020). Furthermore, the disposal of paper-based products, particularly single-use items, contributes to a number of problems that necessitate robust waste management solutions (Méndez et al 2009).

Nevertheless, the industry has certain environmental benefits compared with alternative materials. Paper is inherently recyclable, allowing for the recovery and reuse of fibers to create new products. Furthermore, the transition toward agro-based paper production can utilize agricultural residues as an alternative to wood fibers. Indeed, studies have demonstrated that the manufacture of agro-based paper utilizes up to 90% less water and 60% less energy than traditional wood-based paper production, thereby underscoring its potential for resource conservation (Pydimalla et al 2023). Moreover, ongoing research into bio-derived materials derived from agricultural waste presents promising avenues for the development of environmentally friendly packaging solutions.

The social impacts of the industry are complex and multifaceted. On the one hand, the industry provides employment opportunities and contributes to economic development, particularly in rural communities where agro-based paper production thrives (Otieno et al 2021). Moreover, the industry plays a pivotal role in supporting education, communication, and cultural preservation through the production of paper-based materials (Aithal and Shenoy 2016). Nevertheless, concerns regarding fair labor practices, human rights, and the impact of globalized production on local communities necessitate careful consideration (Mattila et al 2018). Furthermore, the industry's environmental practices can influence consumer perceptions and purchasing decisions, emphasizing the importance of transparency and responsible sourcing (Parguel et al 2011; Lewandowska et al 2017).

To ensure a sustainable future, the paper and paper-based packaging industry must navigate the complex environmental and social impacts it currently faces. To do so, it is crucial that the industry embraces sustainable practices, such as responsible forestry management, increased use of recycled content, and the development of innovative bio-based materials. Simultaneously, it is essential that the industry prioritizes fair labor practices, engages with local communities, and fosters transparency, to mitigate negative social impacts and build a more equitable and sustainable industry. By addressing both its environmental and social responsibilities, the paper and paper-based packaging industry can continue to

meet the needs of society while contributing to a more sustainable and just future.

The Purpose and Significance of Sustainability Reporting for Companies

The practice of sustainability reporting has emerged as a crucial aspect of business operations for companies across various industries, including the paper and pulp sectors. Reporting provides a framework for transparently communicating their environmental, social, and economic performance to stakeholders. The primary objective of sustainability reporting is to disclose a company's impacts on the environment and society. This enables stakeholders to assess the company's sustainability performance and hold it accountable for its actions. Such transparency fosters trust and credibility with stakeholders, including investors, customers, employees, and communities, who increasingly demand information about environmental and social responsibility.

Sustainability reports represent a valuable instrument for companies to monitor their advancement toward sustainability objectives, identify areas for enhancement, and benchmark their performance against industry counterparts. By meticulously collating and analyzing data on their environmental and social impacts, companies can gain invaluable insights into their operations and make well-informed decisions to enhance their sustainability performance. This data-driven approach enables companies to assess the efficacy of their sustainability initiatives, identify potential risks and opportunities, and develop strategies for continuous improvement.

Public disclosure of sustainability goals and performance incentivizes companies to develop and implement innovative solutions that address environmental and social challenges. This can result in the adoption of cleaner technologies, more efficient resource management, and the development of new products and services with reduced environmental footprints. Furthermore, sustainability reporting can facilitate collaboration among companies, industry associations, and other stakeholders to collectively address sustainability issues and promote industry-wide best practices.

The Role of Transparency and Accountability in Driving Sustainable Practices

Transparency and accountability are fundamental pillars for driving sustainable practices within companies and across industries. Transparency, characterized by open and honest communication about environmental, social, and economic performance, enables stakeholders to make informed decisions and hold companies accountable for their actions. Companies that openly disclose their sustainability goals, strategies, and performance data, create a culture of accountability that builds trust and credibility with stakeholders. This, in turn, incentivizes companies to prioritize sustainability and continuously improve their practices to meet stakeholder expectations.

Transparency plays a crucial role in promoting responsible environmental management. Companies that disclose their environmental impacts, such as greenhouse gas emissions, water usage, and waste generation provide stakeholders with the necessary information to assess their environmental performance. This transparency encourages companies to adopt cleaner technologies, reduce their environmental footprint, and invest in sustainable solutions to mitigate their impacts.

It is similarly important for companies to be held to account to encourage them to embrace social responsibility. Companies disclosing their social impacts, including labor practices, human rights, and community engagement demonstrate their commitment to ethical conduct and social well-being. Such accountability encourages companies to uphold high social standards, promote fair labor practices, and contribute positively to the communities in which they operate. Moreover, accountability mechanisms, such as external audits and stakeholder engagement processes, provide further assurance that companies are meeting their social responsibilities.

Together, transparency and accountability constitute a potent force for driving sustainable practices. The adoption of these principles by companies engenders a culture of continuous improvement, innovation, and responsible business conduct, thereby contributing to a more sustainable and equitable future.

Purpose of the Research and Contributions to Scientific Literature

This research involves a comprehensive, comparative analysis of the sustainability performance of four prominent companies within the Turkish paper and paper-based packaging industry. Sustainability strategies, initiatives, and performance data were used to illuminate the diverse sustainability pathways and to demonstrate a deeper understanding of the complexities and opportunities within the sector.

Firstly, the research offers a unique comparative assessment of sustainability practices across industry segments within the paper and paper-based packaging sector. This comparative approach transcends the limitations of single-case studies by providing valuable insights into the diverse challenges and opportunities faced by companies operating in varying contexts, from regulatory landscapes to resource availability and cultural nuances. By showcasing best practices and identifying areas for improvement across different companies, the research facilitates cross-learning and knowledge transfer within the industry, paving the way for a more collaborative and informed approach to sustainability.

The study also examines the ongoing discourse surrounding the measurement and evaluation of corporate sustainability performance. By utilizing established sustainability indicators and meticulously evaluating company performance across environmental, social, and economic dimensions, the research constructs a holistic framework for assessing sustainability progress and identifying areas necessitating further development. This comprehensive framework transcends the limitations of siloed approaches to sustainability by considering the interconnectedness of environmental, social, and economic factors, providing a more nuanced and integrated understanding of corporate sustainability performance.

Thirdly, the research underscores the paramount importance of transparency and data disclosure to foster corporate accountability and propelling sustainability performance. The study examines the level of transparency exhibited by each company to identify best practices in sustainability reporting and underscores the indispensable need for standardized and comprehensive disclosure of environmental, social, and economic data. Increased transparency not only empowers stakeholders with information for making informed decisions but also provides an incentive for companies to continuously improve their sustainability performance and contribute to a more sustainable and equitable future.

Finally, this research contributes to the growing body of knowledge on sustainable development within the paper and paper-based packaging industry. Identifying key challenges and opportunities across different geographic regions and industry segments can help create a deeper understanding of sustainability trends within the paper and packaging sector and inform future research directions. While the findings offer potential insights for industry stakeholders, policymakers, and researchers, it is important to acknowledge that the analysis is based on company-reported data that may present inherent limitations and potential biases. Further research, employing diverse methodologies and data sources, is encouraged to corroborate these findings and strengthen their implications for stakeholders across the industry. This includes exploring innovative solutions for mitigating environmental impacts, promoting responsible sourcing practices, fostering social equity and well-being within the workforce, and ensuring economic viability and the creation of shared value for all stakeholders.

METHODOLOGICAL PROCEDURES

Definition of the Case Report

A total of 13 companies are currently listed on the Borsa Istanbul (BIST), operating in the paper and

paper product printing sector in Turkey. This study employed a comparative case study approach focusing on four companies within the Turkish paper and packaging industry: Duran Dogan, Kartonsan, Mondi Group, and Viking Kağıt. These companies were selected based on a purposeful sampling strategy designed to 1) represent a diverse cross-section of the industry, 2) provide insights into both local and global sustainability practices, and 3) facilitate a comparative analysis of the influence of global trends on local operations. The companies were used to examine the following questions:

1. How do the sustainability approaches and performance of domestic Turkish paper and packaging companies compare to those of a multinational company operating within the same national context?
2. What are the key similarities and differences in their sustainability strategies, initiatives, and performance, and what factors might contribute to these variations?
3. To what extent do global sustainability trends and standards influence the practices of local companies operating in Turkey?

The inclusion of Mondi Group, a multinational company with a well-established global sustainability strategy provided a valuable benchmark for assessing the extent to which global sustainability trends and standards have been adopted by domestic Turkish companies. By analyzing the similarities and differences in their approaches, this study offers insights into the unique challenges and opportunities faced by companies operating at different scales and the potential influence of global sustainability frameworks on local practices within the Turkish paper and packaging industry.

Analysis of Mondi Group's sustainability performance in this study was specifically limited to their Turkish operations. This approach ensured a more direct and meaningful comparison with the domestic companies, focusing on their performance within the same national context and regulatory environment.

By employing this purposeful sampling strategy and providing a clear and transparent rationale, this study aimed to contribute to a deeper understanding of the multifaceted sustainability landscape within the paper and packaging industry and offer insights for both local and global stakeholders.

Identification of Indicators and Sustainability Index Structure

This study employed a set of established sustainability indicators encompassing environmental, social, and economic dimensions. These indicators were selected based on their relevance to the paper and packaging industry and their alignment with widely recognized sustainability frameworks, such as the Global Reporting Initiative (GRI) Standards and the Sustainability Accounting Standards Board (SASB) industry standards. The indicators were organized into three distinct categories, each representing a key dimension of sustainability (Feil et al 2015; Feil et al 2017; Feil et al 2022):

1. Environmental Indicators: This category focused on the company' environmental impact and their efforts to minimize their ecological footprint. The specific scoring considerations for each indicator are detailed below:

Hazardous Waste Generation (0-0.3: high generation with limited mitigation; 0.4-0.7: moderate generation with some mitigation efforts; 0.8-1.0: minimal generation with comprehensive mitigation and transparency): Assesses the volume of hazardous waste generated, the implementation of reduction and mitigation strategies, and the transparency of reporting.

Waste Disposal Practices (0-0.3: high reliance on landfill with limited recycling; 0.4-0.7: moderate landfill use with some recycling efforts; 0.8-1.0: minimal landfill use with comprehensive waste diversion and circularity strategies): Evaluates the company's approach to waste disposal, including landfill use, recycling rates, and implementation of circular economy initiatives.

Treatment of Effluents (0-0.3: inadequate treatment with noncompliance issues; 0.4-0.7: basic treatment with some compliance challenges; 0.8-1.0: advanced treatment with full compliance and monitoring of key parameters): Assesses the quality of effluent treatment, adherence to discharge regulations, and monitoring of key water quality parameters.

Recycling of Waste (0-0.3: limited recycling with low rates; 0.4-0.7: moderate recycling with some innovative approaches; 0.8-1.0: extensive recycling with industry-leading innovation and closed-loop systems): Evaluates the extent of recycling efforts, the use of innovative technologies, and the implementation of closed-loop systems for material recovery and reuse.

Atmospheric Emissions (0-0.3: high emissions with limited mitigation; 0.4-0.7: moderate emissions with some reduction efforts; 0.8-1.0: minimal emissions with science-based targets and comprehensive strategies): Assesses the volume of greenhouse gas emissions, the implementation of reduction strategies, and the setting of science-based targets aligned with global climate goals.

Recycling and Reuse of Products (0-0.3: limited product recyclability; 0.4-0.7: moderate recyclability with some design for circularity; 0.8-1.0: high product recyclability with a comprehensive focus on circular economy principles): Evaluates the recyclability of the company's products, the incorporation of design for circularity principles, and the company's commitment to a circular economy.

Renewable Energy Utilization (0-0.3: minimal or no use of renewable energy; 0.4-0.7: moderate use of renewable energy with plans for expansion; 0.8-1.0: extensive use of renewable energy with ambitious targets and investments): Assesses the percentage of energy sourced from renewable sources, investments in renewable energy infrastructure, and the setting of targets for renewable energy adoption.

Energy Efficiency (0-0.3: low energy efficiency with limited improvement; 0.4-0.7: moderate energy efficiency with some initiatives; 0.8-1.0: high energy efficiency with industry-leading performance and continuous improvement): Evaluates the company's energy efficiency performance, the implementation of energy-saving measures, and its progress toward improving energy efficiency.

Use of Renewable Materials (0-0.3: minimal use of renewable materials; 0.4-0.7: moderate use of renewable materials with some sourcing challenges; 0.8-1.0: extensive use of renewable materials with responsible sourcing practices): Assesses the percentage of raw materials sourced from renewable sources, the implementation of responsible sourcing policies, and efforts to diversify the sourcing of renewable materials.

Environmental Compliance (0-0.3: significant noncompliance issues; 0.4-0.7: some compliance challenges; 0.8-1.0: full compliance with environmental regulations and implementation of robust management systems): Evaluates the company's compliance with environmental regulations and permits, the implementation of environmental management systems, and the effectiveness of monitoring and auditing procedures.

Water Consumption (0-0.3: high water consumption with limited reduction efforts; 0.4-0.7: moderate water consumption with some water-saving initiatives; 0.8-1.0: minimal water consumption with comprehensive water stewardship programs): Assesses the volume of water withdrawal, the implementation of water-saving measures, and the company's participation in water stewardship initiatives.

2. Social Indicators: This category assesses the company' social responsibility and its impact on employees, communities, and other stakeholders. The scoring considerations for each social indicator are as follows:

Employee Satisfaction (0-0.3: low satisfaction with limited engagement; 0.4-0.7: moderate satisfaction with some initiatives to improve well-being; 0.8-1.0: high satisfaction with comprehensive programs and a focus on work–life balance): Evaluates the level of employee satisfaction, the existence and effectiveness of employee

engagement programs, and the company's efforts to promote work–life balance and well-being.

Employee Training and Development (0-0.3: limited training opportunities; 0.4-0.7: moderate training programs with some focus on skills development; 0.8-1.0: extensive training opportunities covering a wide range of topics, including sustainability and leadership): Assesses the availability and scope of employee training programs, covering technical and soft skills development, leadership training, and sustainability awareness.

Serious and Fatal Accidents (0-0.3: high incidence of accidents and fatalities; 0.4-0.7: moderate accident rate with some safety programs in place; 0.8-1.0: very low accident rate with a strong safety culture and commitment to zero harm): Evaluates the company's safety performance based on the frequency and severity of accidents and fatalities, the existence and effectiveness of safety programs, and the company's commitment to achieving a zero-harm workplace.

Employee Health and Well-being (0-0.3: limited or no health and well-being programs; 0.4-0.7: Basic health and safety programs with some focus on well-being; 0.8-1.0: Comprehensive health and well-being programs with a focus on mental and physical health): Assesses the availability and comprehensiveness of health and well-being programs, including mental health support, health screenings, and initiatives promoting healthy lifestyles.

Child Labor Policies (0-0.3: evidence of child labor practices; 0.4-0.7: limited or ineffective policies; 0.8-1.0: zero-tolerance policy for child labor with comprehensive monitoring and enforcement mechanisms): Evaluates the company's policies on child labor, its adherence to international standards, and the effectiveness of monitoring and enforcement mechanisms within the company and its supply chain.

Management of Community Impacts (eg noise, dust) (0-0.3: significant negative community impacts; 0.4-0.7: moderate community impacts with some mitigation efforts; 0.8-1.0: minimal community impacts with proactive engagement and effective mitigation measures): Assesses the company's impact on surrounding communities, particularly relating to noise, dust, and other potential environmental disturbances, and its efforts to mitigate those impacts and engage with communities.

Business Ethics and Transparency (0-0.3: evidence of unethical or corrupt practices; 0.4-0.7: limited or ineffective policies; 0.8-1.0: strong ethical principles and transparent reporting on business practices and governance): Evaluates the company's commitment to ethical business practices, the existence and implementation of anticorruption policies, and the level of transparency in reporting on business conduct and governance structures.

3. Economic Indicators: This category evaluates the company' economic performance and their contributions to sustainable economic development. The scoring considerations are:

Sales Revenue (N/A): Evaluating sales revenue as a sustainability indicator necessitates a detailed contextual analysis, including industry specifics and economic conditions, making a direct score assignment challenging.

Operating Profit (N/A): Similar to sales revenue, assessing operating profit as a sustainability indicator requires a nuanced understanding of the business environment and industry benchmarks.

Net Profit (N/A): Evaluating net profit within a sustainability context requires a holistic analysis of the company's financial performance and its alignment with sustainable business practices.

Tax Payments (0-0.3: tax avoidance or evasion practices; 0.4-0.7: basic compliance with tax regulations; 0.8-1.0: transparent reporting on tax payments and contributions to local economies): Assesses the company's tax practices, including transparency in reporting, compliance with regulations, and contributions to local economies through tax payments.

Operational Costs and Expenses (N/A): Evaluating operational costs and expenses requires a detailed understanding of the business model, industry specifics, and cost structures, making a standardized score assignment challenging.

Wages and Market Standards (0-0.3: evidence of unfair labor practices or below-standard wages; 0.4-0.7: basic compliance with wage regulations; 0.8-1.0: fair compensation exceeding legal and industry standards, promoting employee well-being): Assesses the company's compensation practices, adherence to wage regulations, and efforts to promote employee well-being through fair and competitive wages and benefits.

Local Suppliers (0-0.3: minimal or no engagement with local suppliers; 0.4-0.7: moderate engagement with some local sourcing; 0.8-1.0: high engagement with local suppliers, fostering local economic development and resilient supply chains): Evaluates the company's engagement with local suppliers, the percentage of procurement from local sources, and the impact of sourcing practices on local economic development and supply chain resilience.

Data Collection and Analysis

This study employed a mixed-methods approach, combining qualitative analysis with a quantitative scoring system to facilitate a comparative assessment of sustainability performance across the four selected companies.

The data collection process involved a comprehensive review of publicly available data from multiple sources for each company. These sources included:

2022 Sustainability Reports: Integrated reports, standalone sustainability reports, and other relevant company disclosures.

Corporate Websites: Sustainability sections and related information on company websites.

Third-Party Platforms: Independently verified data submitted to platforms such as Carbon Disclosure Project (CDP).

This triangulation approach utilized multiple sources of data to mitigate potential biases and enhance the reliability of the assessment.

The analysis focused on identifying key sustainability initiatives, strategies, and performance data related to the established environmental, social, and economic indicators. For each indicator, the researchers conducted a thorough qualitative assessment of the company's performance, considering various factors, including:

Scope and Scale of Initiatives: The breadth and depth of the company's sustainability initiatives and programs.

Transparency and Data Disclosure: The level of detail and comprehensiveness of the information provided in company disclosures.

Progress Toward Stated Goals: Company' progress in achieving its stated sustainability targets and commitments.

Alignment with Industry Trends and Best Practices: The extent to which company' activities aligned with broader industry trends and international best practices in sustainability.

Performance for each indicator was then assigned a score on a scale of 0 to 1, with 0 representing the lowest possible performance and 1 representing the highest possible performance. This scoring system, while acknowledging its inherent limitations, facilitated a standardized comparison of company performance across different indicators and enabled the identification of areas of strength and weakness within each company' sustainability profile.

The analysis also involved a comparative assessment of the four companies, examining similarities and differences in their sustainability approaches, challenges faced, and opportunities identified. This comparative perspective, informed by both the qualitative assessment and the quantitative scoring system, allowed for a deeper understanding of the diverse sustainability landscape within the paper and packaging industry, highlighting best practices that can be adopted or adapted by other companies within the sector.

FINDINGS

Environmental Sustainability

The paper and packaging industry has significant environmental impacts throughout its value chain,

from raw material sourcing to production processes and waste management (Jones and Comfort 2017).

The commitment of Mondi Group to environmental sustainability was evident across multiple facets of its operations. The company demonstrated exemplary performance in waste management, achieving a score of 0.8 for waste disposal practices. This is due to a 44% reduction in waste sent to landfills since 2020. This was further evidenced by their 0.9 score for recycling waste, which reflected a 74% recycling/reuse rate for production waste and ongoing efforts to identify innovative solutions for remaining waste streams. Furthermore, Mondi's commitment to transitioning toward renewable energy sources was evidenced by its score of 0.8, which reflected its utilization of 78% renewable energy sources and its continued investments in energy self-sufficiency. Nevertheless, the analysis also indicates the necessity for further attention in certain areas. A score of 0.6 for effluent treatment indicated the need to implement of enhanced strategies to manage effluent load, particularly in light of the recent increases in chemical oxygen demand levels. Similarly, while the company was engaged in reducing air emissions and has made progress in mitigating NOx emissions, a score of 0.7 for atmospheric emissions indicated that further efforts are necessary to minimize the overall air quality impacts. Despite these challenges, Mondi's proactive approach to environmental management, including adherence to ISO 14001 standards and ongoing water stewardship initiatives, indicated a commitment to minimizing its environmental footprint and progressing toward a more sustainable future (Table 1).

Kartonsan's environmental performance presented a multifaceted picture, showcasing notable strengths alongside areas necessitating further development. The company demonstrated exceptional performance in waste management, achieving a score of 0.9 for waste recycling. This was due to the 91% utilization of waste paper in coated cardboard production. This achievement, which exceeded European averages, positioned Kartonsan as a leader in circular economy practices within the industry. Furthermore, company' commitment to responsible waste disposal was reflected in a score of 0.8, driven by its "Zero Waste Certificate" and a comprehensive waste management system that prioritized waste reduction, recycling, and responsible disposal of remaining waste streams. Similarly, Kartonsan's focus on water resource management was commendable, achieving a score of 0.8 through the utilization of modern wastewater treatment techniques and the successful implementation of water recovery and reuse initiatives, which have led to a 24% reduction in freshwater consumption. Nevertheless, the analysis also revealed areas that required additional focus and improvement. Although the report acknowledged the importance of controlling greenhouse gas emissions and mentioned measurement and reporting of Scope 1 emissions, the lack of specific reduction targets

Table 1. Environmental indicators used to assess the four Turkish paper and packaging companies.[a]

Environmental indicator	Mondi Group	Kartonsan	Duran Dogan	Viking Kağıt
A1 - Hazardous Waste Generation	0.7	0.7	0.7	0.7
A2 - Waste Disposal	0.8	0.8	0.9	0.9
A3 - Treatment of Effluents	0.6	0.8	0.8	0.7
A4 - Recycling of Waste	0.9	0.9	0.9	0.9
A5 - Atmospheric Emissions	0.7	0.6	0.9	0.7
A6 - Recycling and Reuse of Products	0.9	0.9	0.8	0.9
A7 - Renewable Energy	0.8	0.4	0.5	0.4
A8 - Energy Efficiency	0.7	0.7	0.7	0.7
A9 - Renewable Materials	0.8	0.9	0.7	0.8
A10 - Environmental Compliance	0.8	0.8	0.9	0.9
A11 - Water Consumption	0.7	0.7	0.7	0.7

[a]Values range from 0 (poor) to 1.0 (high) for each parameter.

and strategies resulted in a score of 0.6 for atmospheric emissions. Furthermore, company' current reliance on conventional energy sources, primarily natural gas, for its operations resulted in a score of 0.4 for renewable energy. The planned establishment of a biomass energy plant in 2024 represented a positive step toward the transition to more sustainable energy sources in the future (Table 1).

Duran Dogan's commitment to environmental sustainability was evident across multiple facets of its operations, showcasing a promising trajectory toward a more sustainable future. The company excelled in waste management and circular economy practices, achieving scores of 0.9 for both waste disposal and recycling of waste. Similar to the observations of Jones and Comfort (2017) regarding leading global companies, the four companies examined in this study demonstrated a pronounced focus on waste management and circular economy principles. For instance, Duran Dogan's "Gloss&Green" technology, which eliminated plastic film lamination and promoted recyclability, aligned with the industry-wide trend toward developing sustainable packaging solutions. This technology eliminates the need for plastic film lamination in packaging, resulting in fully recyclable cardboard products, and facilitates the recycling of PET film waste into valuable raw materials for the plastic industry, contributing significantly to circularity and resource conservation. Duran Dogan also demonstrated a strong commitment to responsible water management, achieving a score of 0.8 for effluent treatment through investments in advanced water treatment plants and ongoing efforts to improve water efficiency. Duran Doğan, the inaugural packaging company in Turkey to pledge adherence to international standards for greenhouse gas emissions reporting, was the sole Turkish packaging company to be included in the CDP (Carbon Disclosure Project) 2013 Global 500 report and was bestowed with the CDP Turkey 1st place award. Carbon footprint calculations were conducted annually, encompassing Scope 1, Scope 2, and Scope 3, and were subjected to verification and subsequent reporting to CDP. However, the analysis also revealed areas where further progress was needed to fully realize company' sustainability ambitions. While Duran Dogan is taking positive steps toward renewable energy adoption through investments in solar panels and plans for future renewable energy procurement, its current reliance on conventional energy sources reduced the score for renewable energy to 0.5. While Duran Dogan has established a solid foundation for environmental sustainability, continued efforts and strategic investments are necessary to achieve its ambitious climate goals and fully transition to a low-carbon and circular economy model (Table 1).

Viking Kağıt demonstrated a strong commitment to environmental sustainability, particularly excelling in the areas of waste management and resource recovery. Company' dedication to circular economy principles was evidenced by scores of 0.9 for both waste disposal and recycling of waste. These achievements highlighted Viking Kağıt's leadership in minimizing waste and maximizing resource utilization within its operations. The implementation of a comprehensive waste management system, culminating in the "Zero Waste Certificate," underscored the proactive approach to waste reduction, recycling, and responsible disposal of remaining waste streams. Furthermore, Viking Kağıt's innovative Recyfiber® technology exemplified its commitment to circularity by utilizing recycled beverage cartons to produce eco-friendly tissue paper products, thereby closing the loop and creating value from waste materials. The company also demonstrated responsible water management practices, earning a score of 0.7 for the treatment of effluents. This score reflects adherence to discharge regulations and a significant 30% reduction in its water footprint since the base year 2014; indicating ongoing efforts to conserve water resources. In terms of climate action, Viking Kağıt achieved a score of 0.7 for atmospheric emissions by actively monitoring and reporting its Scope 1 and 2 greenhouse gas emissions, achieving a notable 33% reduction compared with the base year 2010. Although these achievements are commendable, the analysis also

identified opportunities for further enhancing environmental performance. A score of 0.4 for renewable energy underscores the need for increased integration of renewable energy sources within company' operations to further reduce reliance on conventional energy and minimize its carbon footprint. Additionally, expanding the scope of emissions reporting to encompass Scope 3 emissions and developing comprehensive strategies for emissions reductions across the entire value chain are crucial next steps toward achieving greater environmental sustainability and contributing to global climate action goals (Table 1).

While Jones and Comfort (2017) observed variations in company' commitment to climate action, the companies in this study collectively demonstrated a degree of progress toward renewable energy adoption and emissions reductions. This suggested a potential shift within the Turkish paper and packaging industry toward greater emphasis on addressing climate change.

Furthermore, as highlighted by Vivas et al (2024), the global trend toward digitalization is leading to a decline in the availability of recycled paper, posing a significant challenge for the paper industry. This is particularly relevant for the Turkish context, where securing a sustainable supply of raw materials is crucial for the long-term viability of the paper and packaging sector. Moreover, the exploration of alternative fibers, such as agricultural residues or fast-growing plants, as proposed by Pydimalla et al (2023), becomes imperative to mitigate the risk of supply chain disruptions and ensure the continued growth of the industry while minimizing its environmental impact.

Social Sustainability

Mondi Group's approach to social responsibility demonstrates a multifaceted commitment to its employees, communities, and ethical business practices, as revealed through a comprehensive assessment using established social sustainability indicators. Company' efforts to cultivate a positive and enriching work environment for its employees were reflected in a score of 0.75 for employee satisfaction. This score acknowledged the generally positive feedback regarding opportunities for development, a sense of purpose, and overall work–life balance, while also recognizing the need for continued improvement in areas such as inclusivity and psychological safety. Mondi's dedication to fostering employee growth and development was further evidenced by a score of 0.8, highlighting significant investments in upskilling programs, leadership development initiatives, and specialized training on sustainability and safety. Commitment to ethical business practices was also noteworthy, earning a score of 0.9 due to its robust Code of Business Ethics, comprehensive anticorruption policies, and the implementation of the SpeakOut platform, a confidential grievance mechanism accessible to both employees and external stakeholders, ensuring a safe and secure environment for raising concerns. Despite these commendable efforts, the analysis identified areas requiring further attention and improvement. A score of 0.5 for serious and fatal accidents underscored the critical need for continued efforts to enhance safety performance and strive toward the company's zero-harm target. While Mondi actively promotes health and well-being initiatives and provides access to health services and Employee Assistance Programs, a score of 0.7 suggests that further development and expansion of these programs will be essential to ensure comprehensive and accessible support for employee well-being, both physically and mentally (Table 2).

Kartonsan's approach to social responsibility presented a complex picture, with notable strengths in employee development and ethical business practices alongside challenges in employee relations and safety performance. The company demonstrated a commendable dedication to fostering employee growth and expertise, achieving a score of 0.8 for employee training and development. This score reflected Kartonsan's investment in comprehensive training programs covering diverse areas such as technical skills development, occupational health and safety, sustainability awareness, and leadership training, highlighting a commitment to employee upskilling and long-term employability. Furthermore, the company

Table 2. Social indicators used to assess the four Turkish paper and packaging companies.[a]

Social indicator	Mondi Group	Kartonsan	Duran Dogan	Viking Kağıt
S1 - Employee Satisfaction	0.7	0.6	0.7	0.7
S2 - Employee Training and Development	0.8	0.8	0.8	0.8
S3 - Serious and Fatal Accidents	0.5	0.6	0.7	0.8
S4 - Employee Health Evaluation	0.7	0.7	0.7	0.7
S5 - Child Labor	1.0	1.0	1.0	1.0
S6 - Dust Complaints	0.8	0.7	0.7	0.8
S7 - Business Ethics	0.9	0.8	0.8	0.8

[a]Values range from 0 (poor) to 1.0 (high) for each parameter.

reported a strong commitment to ethical business practices, earning a score of 0.8 due to adherence to legal requirements, transparency in reporting, and implementation of ethical guidelines and policies. Kartonsan's proactive approach to uphold human rights and ensure fair labor practices was further evidenced by its perfect score of 1.0 for its zero-tolerance policy against child labor. The analysis also revealed challenges that require attention and improvement. A score of 0.6 for employee satisfaction pointed to potential concerns regarding employee relations and overall satisfaction with working conditions or compensation, particularly considering an ongoing strike initiated by the labor union representing a significant portion of the workforce. Additionally, while Kartonsan prioritized occupational health and safety and operated under the ISO 45001 standard, a score of 0.6 for serious and fatal accidents highlighted the need for continued efforts to enhance safety performance and strive toward the zero-harm target (Table 2).

Duran Dogan's approach to social responsibility revealed a multifaceted commitment to its employees, ethical business practices, and fostering a safe and healthy work environment. Dedication to employee development and upskilling was reflected in a score of 0.8 for employee training and development, highlighting its investment in comprehensive training programs that covered diverse areas such as technical skills, sustainability awareness, leadership development, and responsible supply chain practices. This focus on continuous learning and development not only enhances employee expertise but also contributes to long-term employability and career advancement opportunities within the organization. Furthermore, Duran Dogan demonstrated a strong commitment to ethical business practices, earning a score of 0.8 due to its adherence to ethical labor principles, implementation of a "ethical policy" system for reporting violations, and its proactive approach to upholding human rights across its operations and supply chain. This commitment was further evidenced by its perfect score of 1.0 for its zero-tolerance policy against child labor, ensuring the protection of vulnerable individuals and adherence to responsible labor practices. The focus on occupational health and safety was also noteworthy, achieving a score of 0.7 due to its ISO 45001 certification and implementation of comprehensive safety measures and training programs. Despite these commendable efforts, the analysis identified limitations in available data, particularly concerning employee satisfaction. Although the company' focus on employee engagement and well-being initiatives suggested a positive work environment, the lack of detailed data on employee satisfaction surveys limited a more thorough assessment of employee morale, engagement, and overall satisfaction with working conditions and compensation. Addressing this data gap and actively engaging with employees to understand their needs and concerns will be crucial for Duran Dogan to further enhance its social performance and create a truly inclusive and supportive work environment (Table 2).

Viking Kağıt's approach to social responsibility revealed a strong commitment to its employees, fostering a safe and healthy work environment, and upholding ethical business practices. Company' dedication to employee development and

upskilling was reflected in a score of 0.8 for employee training and development. This score highlighted investment in comprehensive training programs spanning various areas, including technical skills, sustainability awareness, leadership development, and responsible supply chain practices. This emphasis on continuous learning not only enhanced employee expertise and adaptability but also contributed to long-term employability and created opportunities for career advancement within the organization. Furthermore, Viking Kağıt demonstrated a commitment to occupational health and safety, achieving a score of 0.8. This score reflected the proactive approach to managing workplace safety through risk assessments, implementation of preventive measures, and comprehensive safety training programs for both employees and contractors. The absence of reported significant incidents or accidents further suggested a strong safety culture embedded within operations. Additionally, adherence to ethical business practices, including a zero-tolerance policy for child labor, contributes to a score of 0.8 in this category. This commitment aligned with Yaşar Holding's broader dedication to responsible business conduct and respect for human rights throughout its subsidiaries and supply chains. Despite these positive findings, the analysis also identified a need for increased transparency and data disclosure to facilitate a more comprehensive assessment of social performance. While the focus on employee engagement and well-being initiatives suggested a positive work environment, the limited availability of specific data on employee satisfaction surveys prevented a more thorough evaluation of employee morale, engagement levels, and overall satisfaction with working conditions and compensation. Similarly, while the company's alignment with Yaşar Holding's commitment to diversity and inclusion indicated a positive direction, the lack of specific data on diversity and inclusion initiatives limited a comprehensive assessment of its progress and effectiveness in promoting a diverse and inclusive workplace. Addressing these data gaps and actively engaging with employees to understand and respond to their needs and concerns will be crucial for Viking Kağıt to further enhance its social performance and build a truly inclusive and equitable work environment for all (Table 2).

Our study found that the participating companies demonstrated a consistent commitment to fair compensation and positive employee relations. All four companies adhered to collective bargaining agreements with relevant labor unions, ensuring that employee wages and benefits were negotiated fairly and transparently. This emphasis on equitable labor practices was crucial, as working conditions within the forest, paper, and packaging industry could significantly impact employee satisfaction and overall organizational performance. Research indicated that conducive working conditions, including fair remuneration and opportunities for professional development, were essential for fostering job satisfaction (Arokiasamy 2019; Mo & Borbon 2022). Conversely, inadequate support from management, limited opportunities for intellectual growth, or generally poor working conditions could contribute to employee dissatisfaction and increased turnover intentions (Herliana et al 2021). This was particularly relevant in labor-intensive industries like forest, paper, and packaging, where employee morale directly influenced productivity and, ultimately, the quality of products and services delivered (Heimerl et al 2020; Bañuls et al 2018).

Economic Sustainability

Mondi Group's approach to economic sustainability demonstrated a commitment to responsible practices that contributed to the well-being of local communities and upheld fair labor standards, as revealed through the analysis of key economic sustainability indicators. Dedication to transparency and accountability in its tax practices was reflected in a score of 0.8 for tax payments, highlighting its significant contributions to local economies through responsible tax contributions. Furthermore, Mondi's commitment to fair compensation was evidenced by a score of 0.8 for wages and market standards, underscoring its adherence to legal and industry benchmarks for wages and benefits, ensuring fair and equitable treatment of its employees. Mondi's prioritization

of local sourcing further strengthened its economic sustainability performance, earning a score of 0.8 for its emphasis on procuring goods and services from local suppliers. This focus on local procurement not only contributed to local economic development but also fostered community resilience and promoted sustainable supply chains. However, the analysis acknowledged limitations in available data, particularly concerning metrics such as sales revenue, operating profit, and net profit. Assessing the sustainability implications of these indicators will require a more nuanced understanding of industry-specific benchmarks, economic contexts, and overall financial performance about its sustainable business practices (Table 3).

Kartonsan's approach to economic sustainability also revealed a commitment to responsible practices that contributed to the economic well-being of local communities and upheld fair labor standards. Dedication to transparency and accountability in its tax contributions was reflected in a score of 0.8 for tax payments, highlighting its significant role as a contributor to the Turkish economy and its support for public services and infrastructure through responsible tax practices. Furthermore, Kartonsan demonstrated a commitment to fair compensation, earning a score of 0.7 for wages and market standards. Adherence to legal and industry benchmarks for wages and benefits, ensuring equitable treatment of its employees while also recognizing potential areas for improvement, particularly in light of the ongoing labor strike related to negotiations for a new collective bargaining agreement. Kartonsan's prioritization of local sourcing further strengthened its economic sustainability performance, achieving a score of 0.8 for its emphasis on procuring goods and services from local suppliers. This focus on local procurement not only stimulates local economic development and job creation but also fosters community resilience and promotes sustainable supply chain practices by reducing transportation distances and associated environmental impacts. However, the analysis acknowledged limitations in available data, particularly concerning metrics such as sales revenue, operating profit, and net profit. A more comprehensive evaluation of Kartonsan's overall economic sustainability performance would require a deeper understanding of these financial indicators within the context of industry-specific benchmarks, economic fluctuations, and the strategic alignment of financial performance with sustainable business practices (Table 3).

Duran Dogan's approach to economic sustainability also revealed a multifaceted commitment to responsible financial practices, fair labor standards, and contributions to local economic development. The company demonstrated transparency and accountability in its tax contributions, receiving a score of 0.8 for tax payments, highlighting its role as a responsible corporate citizen and its support for public services and infrastructure development within the Turkish economy. Furthermore, Duran Dogan's commitment to local sourcing was evident in its score of 0.8 for prioritizing procurement from local suppliers. This practice not only stimulates local economic growth and job creation but also fosters resilient supply chains by reducing dependence on long-distance transportation, thereby minimizing

Table 3. Economic indicators used to assess the four Turkish paper and packaging companies.[a]

Economic indicator	Mondi Group	Kartonsan	Duran Dogan	Viking Kağıt
E1 - Sales Revenue	N/A	N/A	N/A	N/A
E2 - Operating Profit	N/A	N/A	N/A	N/A
E3 - Net Profit	N/A	N/A	N/A	N/A
E4 - Tax Payments	0.8	0.8	0.8	0.8
E5 - Operational Costs and Expenses	N/A	N/A	N/A	N/A
E6 - Wages and Market Standards	0.8	0.7	0.7	0.7
E7 - Local Suppliers	0.8	0.8	0.8	0.7

[a]Values range from 0 (poor) to 1.0 (high) for each parameter.

associated environmental impacts and promoting regional economic development. Although the focus on employee well-being and ethical labor practices suggested an inherent commitment to fair compensation, the lack of specific data on wages and benefits limited a comprehensive assessment in this area. A score of 0.7 was assigned for wages and market standards, acknowledging the potential need for increased transparency and disclosure regarding employee compensation practices. Additionally, the analysis recognized limitations in the available data concerning metrics such as sales revenue, operating profit, and net profit. Evaluating these financial indicators within the context of sustainable business practices necessitates a more nuanced understanding of industry-specific benchmarks, economic fluctuations, and strategic alignment of financial performance with long-term sustainability goals. Future research and reporting should focus on providing a more comprehensive and contextualized analysis of these economic indicators to fully assess Duran Dogan's overall contribution to sustainable economic development (Table 3).

Viking Kağıt's approach to economic sustainability demonstrated a commitment to responsible financial practices, fostering local economic development, and upholding fair labor standards. Dedication to transparency and accountability in its tax contributions is reflected in a score of 0.8 for tax payments, signifying its role as a responsible corporate citizen and its contribution to supporting public services and infrastructure development within the Turkish economy. Furthermore, Viking Kağıt's emphasis on local sourcing, particularly for materials and services other than virgin pulp, which is primarily imported due to limited domestic availability, contributed to a score of 0.7 for supporting local economies and fostering resilient supply chains. This preference for local procurement not only stimulates regional economic growth and job creation but also reduces the environmental impacts associated with long-distance transportation, thereby promoting both economic and environmental sustainability. Although specific data on wages and benefits was limited, Viking Kağıt's adherence to a collective bargaining agreement with the Selüloz-İş union and its alignment with Yaşar Holding's commitment to ethical labor practices suggested fair compensation for its employees. However, a score of 0.7 was assigned for wages and market standards to acknowledge the potential need for increased transparency and disclosure regarding specific wage structures and benefits provided to employees. The analysis further recognized limitations in the available data concerning overall financial performance. Evaluating metrics such as sales revenue, operating profit, and net profit within the context of sustainable business practices necessitates a more nuanced understanding of industry-specific benchmarks, economic fluctuations, and the company's strategic alignment of financial performance with long-term sustainability goals. Providing greater transparency and disclosure regarding these financial indicators and demonstrating how financial success translates into positive social and environmental impacts would enable a more holistic assessment of Viking Kağıt's contribution to sustainable economic development and its overall commitment to creating shared value for all stakeholders (Table 3).

CONCLUSIONS

Comparative analysis of the sustainability performance of the four companies revealed a diverse approach to sustainability within the Turkish paper and packaging industry. While the companies all demonstrated a commitment to environmental and social responsibility, their performance and areas of emphasis varied, likely influenced by factors such as company size, access to resources, and specific product lines.

All four companies exhibited a strong commitment to waste management and circular economy principles. This shared focus was evident in Mondi Group's achievement of a 44% reduction in waste to landfill since 2020; Kartonsan's 91% utilization of wastepaper in its coated cardboard production, Duran Dogan's development of "Gloss&Green" technology, and Viking Kağıt's innovative Recyfiber® technology, which utilizes

recycled beverage cartons. These initiatives align with the industry's growing recognition of the environmental and economic benefits of minimizing waste and maximizing resource recovery.

However, company approaches to energy management and carbon emissions reduction varied. While Mondi Group and Duran Dogan have established ambitious science-based targets for emissions reduction, Kartonsan and Viking Kağıt primarily focused on energy efficiency and responsible sourcing. This difference highlighted a potential challenge for the Turkish paper and packaging industry: balancing the cost-competitiveness of conventional energy sources with the need to transition to renewables to achieve more significant emissions reductions.

The analysis also revealed variations in social performance. Mondi Group stood out with its comprehensive approach to employee well-being, actively measuring employee satisfaction, promoting diversity and inclusion, and implementing a robust grievance mechanism. Although the other companies demonstrated commitment to fair labor practices and employee training, the limited data on employee satisfaction and diversity initiatives made it difficult to comprehensively assess their social performance.

Furthermore, this study highlighted industry progress toward adopting circular bioeconomy principles, as evidenced by initiatives such as using recycled content, developing biodegradable materials, and investing in waste reduction strategies. However, the decline in the availability of recycled paper, presents a challenge, particularly in the Turkish context. Exploring alternative fibers, such as agricultural residues or fast-growing plants may be necessary to mitigate supply chain risks and ensure the industry's long-term sustainability.

This research underscored the importance of transparency and data disclosure in driving sustainable practices within the paper and packaging industry. Although Mondi Group provided comprehensive data, the other companies offered limited information on how their economic performance translated into positive social and environmental impacts. Adopting integrated reporting frameworks that connect financial performance with environmental and social outcomes can enhance transparency and demonstrate the value of a holistic approach to sustainability.

While the results are based on company-reported data, they offer valuable insights into the current state of sustainability in the Turkish paper and packaging industry and illuminate key areas for future research. Further investigation into the economic feasibility and scalability of circular economy solutions, the social implications of a circular bioeconomy, and the role of policy in driving industry-wide sustainability improvements is warranted. Moreover, exploring emerging technologies to enhance transparency and traceability within the supply chain can contribute to a more responsible and sustainable paper and packaging industry.

Future Research Directions

Building upon the findings of this comparative analysis, several avenues for future research emerge. Investigating the economic feasibility and scalability of circular economy solutions within the Turkish paper and packaging industry is crucial, exploring factors, such as investment costs, technological advancements, and consumer acceptance. Further research could also delve deeper into the social implications of the transition to a circular bioeconomy, examining its impact on employment, community development, and social equity within the sector. Additionally, exploring the role of policy interventions in incentivizing sustainable practices and promoting industry-wide collaboration on resource efficiency and emissions reduction presents a significant research opportunity. Moreover, investigating the potential of emerging technologies, such as blockchain and artificial intelligence, to enhance transparency and traceability within the paper and packaging supply chain could provide valuable insights for promoting responsible sourcing and ethical production practices. Finally, comparative studies expanding the scope to encompass other emerging economies could shed light on the broader challenges and opportunities associated with

sustainable development within the global paper and packaging industry.

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