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Master in Supply Chain Management

Postgraduate Dissertation

Sustainability practices and their impact on business performance in
aluminum sector

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Patras, Greece, June 2025

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Abstract

Sustainability has become a critical priority across industrial sectors, particularly in energy-intensive industries such as aluminum manufacturing. As environmental, social, and economic pressures mount, companies are increasingly expected to adopt sustainable practices not only to meet regulatory requirements but also to enhance competitiveness and long-term viability. This study aimed to investigate the extent to which sustainability practices are implemented in the aluminum sector in Greece and to assess their perceived impact on business performance. Data were collected using an online questionnaire distributed via Google Forms to 60 employees working in midstream aluminum operations. The findings indicate that environmental sustainability practices—such as energy-saving initiatives, recycling programs, and carbon reduction efforts—are widely implemented. Social practices, including worker safety and community engagement, are also present, although uncertainty remains regarding ethical labor standards. Economically, many companies invest in sustainable technologies, yet face significant barriers such as high costs and limited government support. Despite positive employee perceptions of sustainability's benefits, statistical analysis revealed no significant correlations between sustainability practices and financial performance, profitability, or competitiveness. The results suggest that while sustainability practices are being adopted and perceived positively by employees, their measurable impact on business performance remains unclear. Further integration of sustainability into corporate strategy, improved performance tracking systems, and broader stakeholder engagement are necessary to realize and demonstrate the full business value of sustainable management.

Keywords

Sustainability, aluminum industry, business performance, environmental practices, social responsibility

Πρακτικές βιωσιμότητας και ο αντίκτυπός τους στην επιχειρηματική απόδοση στον τομέα του αλουμινίου

Κωνσταντίνος Κολώνιας

Περίληψη

Η βιωσιμότητα έχει καταστεί κρίσιμη προτεραιότητα σε όλους τους βιομηχανικούς τομείς, ιδίως σε ενεργοβόρους κλάδους όπως η κατασκευή αλουμινίου. Καθώς οι περιβαλλοντικές, κοινωνικές και οικονομικές πιέσεις αυξάνονται, οι εταιρείες αναμένεται ολοένα και περισσότερο να υιοθετήσουν βιώσιμες πρακτικές όχι μόνο για να ανταποκριθούν στις κανονιστικές απαιτήσεις αλλά και για να ενισχύσουν την ανταγωνιστικότητα και τη μακροπρόθεσμη βιωσιμότητα. Στόχος της παρούσας μελέτης ήταν να διερευνήσει τον βαθμό στον οποίο εφαρμόζονται πρακτικές βιωσιμότητας στον τομέα του αλουμινίου στην Ελλάδα και να αξιολογήσει τον αντιληπτό αντίκτυπό τους στην επιχειρηματική απόδοση. Τα δεδομένα συλλέχθηκαν χρησιμοποιώντας ένα ηλεκτρονικό ερωτηματολόγιο που διανεμήθηκε μέσω του Google Forms σε 60 υπαλλήλους που εργάζονται σε μεσαίες δραστηριότητες αλουμινίου. Τα ευρήματα δείχνουν ότι οι πρακτικές περιβαλλοντικής βιωσιμότητας - όπως πρωτοβουλίες εξοικονόμησης ενέργειας, προγράμματα ανακύκλωσης και προσπάθειες μείωσης του άνθρακα - εφαρμόζονται ευρέως. Οι κοινωνικές πρακτικές, συμπεριλαμβανομένης της ασφάλειας των εργαζομένων και της συμμετοχής της κοινότητας, είναι επίσης παρούσες, αν και η αβεβαιότητα παραμένει σχετικά με τα ηθικά εργασιακά πρότυπα. Από οικονομικής άποψης, πολλές εταιρείες επενδύουν σε βιώσιμες τεχνολογίες, ωστόσο αντιμετωπίζουν σημαντικά εμπόδια, όπως το υψηλό κόστος και η περιορισμένη κρατική υποστήριξη. Παρά τις θετικές αντιλήψεις των εργαζομένων για τα οφέλη της βιωσιμότητας, η στατιστική ανάλυση δεν αποκάλυψε σημαντικές συσχετίσεις μεταξύ των πρακτικών βιωσιμότητας και της οικονομικής απόδοσης, της κερδοφορίας ή της ανταγωνιστικότητας. Τα αποτελέσματα υποδηλώνουν ότι ενώ οι πρακτικές βιωσιμότητας υιοθετούνται και γίνονται αντιληπτές θετικά από τους υπαλλήλους, ο

μετρήσιμος αντίκτυπός τους στην επιχειρηματική απόδοση παραμένει ασαφής. Η περαιτέρω ενσωμάτωση της βιωσιμότητας στην εταιρική στρατηγική, η βελτίωση των συστημάτων παρακολούθησης της απόδοσης και η ευρύτερη συμμετοχή των ενδιαφερόμενων μερών είναι απαραίτητες για την υλοποίηση και την επίδειξη της πλήρους επιχειρηματικής αξίας της βιώσιμης διαχείρισης.

Λέξεις – Κλειδιά

Βιωσιμότητα, βιομηχανία αλουμινίου, επιχειρηματική απόδοση, περιβαλλοντικές πρακτικές, κοινωνική ευθύνη

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1. Introduction

1.1 Background of the Study

The manufacturing sector is under growing pressure to transition toward more sustainable models of operation. This transformation is driven by increasing environmental concerns, social responsibility expectations, and economic imperatives (Dhir et al., 2023; Ahmad & Wong, 2018). In particular, the aluminum industry—known for its high energy demands and environmental footprint—faces urgent calls to adopt more sustainable practices across the entire value chain (Reinsch & Benson, 2022). Within this industry, the aluminum rolling division plays a crucial role, as it converts raw aluminum ingots into semifinished products such as sheets, coils, and foils used in packaging, construction, automotive, and aerospace sectors (World Economic Forum, 2020).

Aluminum production, especially the rolling process, is energy-intensive and contributes significantly to carbon emissions and industrial waste. Despite aluminum being a recyclable material with potential for a circular economy, its primary production and processing stages pose sustainability challenges due to their reliance on fossil fuels and water, and the generation of byproducts such as red mud and fluoride compounds (Cullen & Allwood, 2013). As global awareness of climate change intensifies, stakeholders—including regulators, investors, consumers, and local communities—are increasingly demanding greater accountability from aluminum producers regarding their environmental and social performance (Reinsch & Benson, 2022).

Sustainable management in an aluminum rolling division encompasses a wide range of practices aimed at minimizing environmental impacts, enhancing social responsibility, and ensuring long-term economic viability. These practices include energy efficiency initiatives, waste reduction and recycling programs, water conservation, occupational health and safety measures, employee training, and community engagement. Companies are expected to integrate these practices into their strategic decision-making processes, aligning them with sustainability frameworks such as the United Nations Sustainable Development Goals (SDGs) and environmental, social, and governance (ESG) criteria (Ioannou & Serafeim, 2015).

In recent years, many companies in the aluminum sector have begun to publish sustainability reports following international standards such as the Global Reporting Initiative (GRI).

These reports serve as a tool for transparency and help track progress toward sustainability targets. However, the adoption and effectiveness of sustainable management strategies vary significantly across regions and companies due to differences in technological capabilities, resource availability, regulatory environments, and organizational cultures (Hou et al., 2024; Reinsch & Benson, 2022).

Moreover, research indicates that sustainability initiatives can drive innovation, reduce operational costs, and enhance brand reputation, thereby contributing to improved business performance (Elkington, 1997). Despite these benefits, implementing sustainable practices in aluminum rolling operations remains a complex endeavor, often hindered by high upfront costs, resistance to change, and gaps in knowledge or leadership commitment (Hou et al., 2024).

1.2 Problem Statement

The aluminum industry, while essential to modern infrastructure and product development, is simultaneously one of the most energy-intensive sectors globally. This inherent contradiction—between industrial necessity and environmental impact—presents a significant challenge to achieving sustainable development within the sector. Despite increasing awareness and efforts to integrate sustainable practices, the implementation of comprehensive and effective sustainable management in aluminum rolling divisions remains uneven and insufficiently understood (World Economic Forum, 2020; Hou et al., 2024; Reinsch & Benson, 2022).

One of the critical issues facing aluminum rolling divisions is the difficulty of translating sustainability goals into measurable and actionable management practices. Although sustainability frameworks exist, companies often struggle to operationalize these within the constraints of production efficiency, cost reduction, and market competitiveness (Hou et al., 2024; Reinsch & Benson, 2022). Many organizations adopt isolated initiatives (e.g., recycling programs or energy-saving technologies) without embedding sustainability into their core management systems. This fragmented approach undermines the long-term benefits of sustainability and limits its impact on overall business performance and stakeholder value (Ioannou & Serafeim, 2015).

Moreover, there is a lack of standardized methods to assess and benchmark sustainable management practices within the aluminum rolling segment. While large multinational corporations may have the resources to implement ESG strategies and report on sustainability, smaller or regionally focused aluminum rolling companies often lack the expertise, tools, or incentives to do so. This results in inconsistencies across the industry and makes it difficult to evaluate the effectiveness of various sustainability approaches or identify best practices (Setyaningsih, Widjojo & Kelle, 2024).

Another pressing concern is the limited availability of empirical research focusing specifically on sustainable management within aluminum rolling operations. Most existing studies either address sustainability in the aluminum industry broadly or concentrate on upstream processes like mining and smelting (Raabe, 2023; Georgitzikis et al., 2021; Safarov & Hasanov, 2024). As a result, there is a significant knowledge gap regarding how sustainability is managed at the midstream level—particularly in rolling divisions that are critical for product finalization and supply chain integration.

1.3 Aim and Research Questions

The aim of this study is to evaluate the implementation and effectiveness of sustainable management practices in the aluminum sector, with a particular focus on how these practices align with environmental, social, and economic sustainability dimensions.

The research is guided by the following key questions:

1. To what extent are environmental, social, and economic sustainability practices implemented in the aluminium sector?
2. How familiar and engaged are the employees of aluminum companies with sustainability principles and initiatives?
3. What are the perceived challenges and barriers to implementing sustainable management practices in aluminium companies?
4. What is the relationship between sustainability practices and business performance indicators such as cost savings, competitiveness, and employee productivity in aluminum companies?

1.4 Significance of the Study

As global industries face mounting environmental and social pressures, sustainability is no longer a peripheral concern—it has become a strategic imperative. This is especially true in the aluminum sector, where energy consumption, emissions, and resource use are significant. Despite this, there remains a gap in the practical understanding of how sustainability is applied and experienced at the operational level, particularly within aluminum rolling divisions. This study addresses that gap by providing empirical insights into sustainable management as practiced within a real-world industrial context.

The significance of this research lies in its multi-dimensional approach to sustainability. By examining environmental, social, and economic practices simultaneously, the study offers a comprehensive assessment of how sustainability is embedded—or lacking—in day-to-day business operations. The inclusion of employee perspectives through a structured questionnaire ensures that findings reflect not just top-down policy declarations, but actual practices and perceptions at various organizational levels.

From a practical standpoint, the findings will be valuable for company leaders and managers seeking to evaluate or refine their sustainability strategies. Insights into employee awareness, engagement, and perceptions of effectiveness can inform more targeted and inclusive sustainability initiatives. The study also identifies barriers such as financial constraints, resistance to change, or lack of regulatory enforcement, offering a clearer view of what must be addressed to enable progress.

Academically, the study contributes to a relatively underexplored area in sustainability research—how midstream manufacturing divisions (like rolling operations) adapt to sustainability demands. While much literature has focused on upstream activities (such as bauxite mining and smelting) or downstream applications, this research bridges the gap and highlights the role of rolling operations in achieving industry-wide sustainability.

In a broader context, the study aligns with global sustainability agendas such as the United Nations Sustainable Development Goals (SDGs), particularly those related to responsible consumption and production (Goal 12), decent work and economic growth (Goal 8), and climate action (Goal 13) (Ioannou & Serafeim, 2015). It underscores the critical role of

organizational behavior and management in driving systemic change and achieving long-term environmental, social, and economic value.

1.5 Structure of the Thesis

This thesis is structured into six chapters, each building upon the previous to provide a comprehensive exploration of sustainable management within an aluminum rolling division company. The first chapter introduces the research topic and outlines the background, problem statement, aim and research questions, significance, and overall structure of the thesis. It sets the foundation for understanding the relevance and direction of the study. The second chapter presents a critical overview of existing literature related to sustainability in the manufacturing industry. It covers definitions of sustainability, sustainable management practices, the triple bottom line (environmental, social, and economic dimensions), challenges in aluminum production, and the connection between sustainability and business performance. The third chapter describes the research design, sample, and data collection methods. It explains the structure of the questionnaire used in the study and outlines the statistical techniques applied for data analysis. The fourth chapter presents the findings from the data collected. It includes descriptive statistics to illustrate the participants' demographic and response patterns, as well as inductive statistical analysis to explore relationships and trends among variables. The fifth chapter interprets the results in light of the research questions and compares them with findings from previous studies. It also discusses limitations encountered during the research process. Finally, the sixth chapter summarizes the key findings, outlines practical implications for sustainable management in the aluminum industry, and offers suggestions for future research based on the results of the study.

2. Literature Review

2.1 Definition of Sustainability in the Manufacturing Industry

Sustainability has emerged as a defining principle for modern industrial systems, especially as environmental degradation, climate change, and social inequality become urgent global concerns (Hariram et al., 2023). The manufacturing industry, being one of the largest consumers of energy and natural resources and a significant contributor to pollution and waste, is central to the global sustainability agenda (Rame, Purwanto & Sudarno, 2024). The concept of sustainability in manufacturing is grounded in the foundational definition by the Brundtland Commission (1987, p. 43), which describes sustainable development as meeting *“the needs of the present without compromising the ability of future generations to meet their own needs”*.

In manufacturing, sustainability involves a balanced integration of three core dimensions—environmental, social, and economic—commonly referred to as the triple bottom line (Elkington, 1997). This framework guides companies to evaluate their performance not only based on financial outcomes but also on environmental stewardship and social responsibility. As such, sustainable manufacturing aims to produce goods in ways that minimize harmful environmental impacts, ensure fair treatment of workers, and support long-term economic growth and innovation (Correia, 2019).

Environmental sustainability in manufacturing emphasizes reducing the ecological footprint of production through energy efficiency, emissions reduction, waste minimization, and resource conservation. Practices include cleaner production techniques, use of renewable energy sources, recycling, and environmentally friendly product design. Social sustainability involves fostering safe working conditions, fair labor practices, and community engagement (Siddique, 2020). This includes employee training, health and safety protocols, diversity and inclusion initiatives, and partnerships with local stakeholders. Economic sustainability, meanwhile, focuses on maintaining profitability and competitiveness while investing in innovations that support long-term operational efficiency and value creation (Manikandan et al., 2024; Siddique, 2020).

According to the United Nations Industrial Development Organization (UNIDO), sustainable manufacturing is defined as *“the creation of manufactured products through*

economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources” (UNIDO, 2011, p. 3). This definition reflects a systems-based approach that integrates environmental and social concerns into every phase of the product life cycle—from raw material sourcing and production to distribution, use, and disposal. It also highlights the role of continuous improvement and innovation in enhancing sustainability performance over time.

In practice, sustainable manufacturing is supported by a range of international standards and tools, including the ISO 14000 environmental management standards, Life Cycle Assessment (LCA), the Global Reporting Initiative (GRI), and sustainability accounting frameworks. These tools help companies monitor, evaluate, and report on their sustainability performance in a structured and transparent manner. Furthermore, emerging trends such as Industry 4.0—characterized by the integration of digital technologies like IoT, AI, and big data—are opening new opportunities for real-time monitoring, predictive maintenance, and resource optimization, thereby enabling more intelligent and adaptive sustainability practices (Stock & Seliger, 2016).

For the purpose of this study, the definition of sustainability provided by the Brundtland Commission (1987)—“meeting the needs of the present without compromising the ability of future generations to meet their own needs”—is adopted as the foundational concept. This definition is widely accepted and provides a holistic, long-term view that aligns well with the goals of sustainable industrial practices.

2.2 Sustainable Management Practices in the Manufacturing Industry

Sustainable management practices in the manufacturing industry have gained substantial traction in response to increasing global concerns about climate change, environmental degradation, social inequality, and economic instability (UNEP, 2010). These practices represent the practical application of sustainability principles within industrial operations and aim to align environmental responsibility, social welfare, and economic performance in a cohesive and long-term strategy. As industries contribute significantly to resource consumption and pollution, their role in achieving sustainable development has become central to international policy and business discourse (Klewitz & Hansen, 2014; UNEP, 2010).

Environmental sustainability within manufacturing typically focuses on minimizing the ecological footprint of production activities. This involves not only reducing emissions, waste, and water usage but also optimizing material efficiency and promoting circularity. Manufacturers increasingly adopt energy-saving technologies, closed-loop recycling systems, and environmentally conscious product design to meet these objectives. Many firms also conduct life cycle assessments (LCA) to evaluate the cumulative environmental impacts of their products and services from raw material extraction to disposal, allowing for more sustainable decision-making across the value chain (Rebitzer et al., 2004; Geng et al., 2012). In recent years, the emergence of digital manufacturing under Industry 4.0 has provided powerful tools such as real-time monitoring, predictive analytics, and automation, which allow companies to track their environmental performance and identify improvement areas with greater precision (Ghobakhloo, 2020; Kamble et al., 2018).

Equally important is the social dimension of sustainability, which addresses how manufacturing organizations treat their workers and interact with the broader community. Social sustainability in this context encompasses workplace safety, employee well-being, fair labor practices, skills development, diversity, and community engagement. Ensuring occupational health and safety is a foundational element, and many firms invest in formal health and safety management systems to prevent accidents and reduce risks (Fernández-Muñiz et al., 2009). Employee training and development—especially in sustainability literacy and digital competencies—are increasingly recognized as essential for building a capable and resilient workforce (Jabbour et al., 2010). Moreover, manufacturers are expected to contribute positively to local communities through education programs, infrastructure development, and ethical sourcing practices that prevent exploitation and promote equity (Porter & Kramer, 2011; ILO, 2017).

Economic sustainability in manufacturing goes beyond financial profitability to emphasize long-term business viability underpinned by resource efficiency, innovation, and resilience to market fluctuations (Shah & Ward, 2007). It involves strategic investments in sustainable technologies and business models that reduce costs over time while enabling compliance with emerging regulations and evolving stakeholder expectations. Practices such as lean manufacturing, total quality management, and sustainable supply chain integration support economic goals while reducing environmental waste and improving operational flexibility (Shah & Ward, 2007; Seuring & Müller, 2008). Firms that adopt eco-innovation—defined

as the development of products and processes that generate less environmental harm—frequently gain competitive advantages in new markets, benefit from improved reputations, and experience stronger relationships with customers and investors (Dangelico & Pujari, 2010; Horbach, 2008).

Despite these advances, the adoption of sustainable management practices is often hindered by a variety of challenges. For many firms, especially small and medium-sized enterprises (SMEs), the financial cost of implementing new technologies or management systems can be a significant barrier. There is often uncertainty about the return on investment from sustainability efforts, particularly in the absence of immediate economic incentives or government support (Testa et al., 2012). Additionally, the lack of specialized knowledge or organizational capacity to effectively integrate sustainability into business strategies further limits progress (Walker et al., 2008). Cultural resistance within companies, where sustainability is perceived as a non-core activity or an external obligation, may also slow adoption unless driven by strong leadership and clearly communicated benefits (Lozano, 2013).

Furthermore, inconsistencies in regulatory enforcement and sustainability standards across countries and industries can create confusion and disincentives. While international frameworks such as the Global Reporting Initiative (GRI), ISO 14001, and the UN Sustainable Development Goals (SDGs) offer guidelines, their uptake and implementation vary widely, often depending on the firm's size, market access, and stakeholder pressures (UNIDO, 2011; IEA, 2020). Nevertheless, the increasing incorporation of environmental, social, and governance (ESG) criteria into investment decisions is encouraging more firms to formalize and report on their sustainability practices, creating greater transparency and accountability across the manufacturing sector (Eccles et al., 2012).

In summary, sustainable management in manufacturing is a complex yet increasingly indispensable component of modern industrial strategy. It demands the deliberate and integrated alignment of environmental care, social responsibility, and economic performance. While significant challenges remain—ranging from financial and cultural barriers to regulatory fragmentation—the potential benefits are substantial. Manufacturers that succeed in embedding sustainability across all aspects of their operations not only reduce risks and improve efficiencies but also enhance their reputation, stakeholder trust, and long-term competitiveness. As global trends push industries toward more responsible

and resilient systems, sustainable management is no longer optional but essential for industrial longevity and societal value creation.

2.3 Environmental, Social, and Economic Practices of Sustainability

Sustainability in the manufacturing industry is often understood and implemented through the lens of the “triple bottom line” framework, which encompasses environmental, social, and economic dimensions (Lozano, 2012). These three pillars form the foundation of sustainable development and are interdependent: environmental protection must be pursued in tandem with social equity and economic viability to ensure long-term resilience and growth. In the manufacturing context, this means adopting practices that minimize ecological harm, foster social well-being, and contribute to stable and responsible economic performance (Elkington, 1997; Lozano, 2012).

Environmental sustainability practices in manufacturing focus on reducing the environmental footprint of industrial operations, which includes energy consumption, greenhouse gas emissions, material waste, and water usage. A core strategy is the implementation of cleaner production techniques, which aim to prevent pollution and waste at the source rather than through end-of-pipe treatments (UNEP, 2010). Manufacturers are increasingly investing in technologies that support energy efficiency, such as high-efficiency motors, advanced process controls, and waste heat recovery systems (Thollander & Ottosson, 2010). Additionally, the integration of renewable energy sources—such as solar, wind, or biomass—into manufacturing processes is gaining momentum as firms seek to reduce carbon intensity and dependence on fossil fuels (IEA, 2020).

Another important environmental practice is the application of Life Cycle Assessment (LCA) to identify the full range of environmental impacts associated with products from raw material extraction to end-of-life disposal. LCA enables manufacturers to design more sustainable products and processes by optimizing material use, improving recyclability, and reducing resource dependency (Rebitzer et al., 2004). Environmental performance monitoring systems, supported by digital technologies such as IoT sensors and data analytics, further enhance manufacturers’ ability to track emissions, water usage, and waste generation in real time (Ghobakhloo, 2020).

Social sustainability in manufacturing encompasses a broad range of practices aimed at improving the quality of life for employees, local communities, and other stakeholders. Internally, this includes ensuring safe and healthy working conditions, promoting fair labor practices, and offering opportunities for training and career development. Employee health and safety management systems (e.g., ISO 45001) help organizations create structured approaches to risk reduction, compliance, and continuous improvement (Fernández-Muñiz et al., 2009).

Manufacturers also play a critical role in promoting diversity, equity, and inclusion within the workplace. This involves equitable hiring practices, equal pay, non-discrimination policies, and fostering a workplace culture that values different perspectives and backgrounds (Avery & McKay, 2006). Additionally, companies are increasingly expected to engage with local communities through initiatives such as educational partnerships, infrastructure development, and local sourcing. These efforts not only support community development but also enhance the company's social license to operate (Porter & Kramer, 2011).

Ethical supply chain management is another vital component of social sustainability. This includes conducting supplier audits to ensure that labor rights are respected throughout the value chain and avoiding business relationships with suppliers involved in exploitative practices, such as child labor or unsafe working conditions (ILO, 2017).

Economic sustainability refers to the capacity of manufacturing firms to remain profitable and competitive while pursuing long-term environmental and social objectives. It emphasizes operational efficiency, innovation, and the strategic allocation of resources to support sustainable growth. Lean manufacturing, for example, reduces material waste, shortens lead times, and lowers production costs—outcomes that align environmental goals with financial performance (Shah & Ward, 2007).

Moreover, many manufacturers are leveraging eco-innovation to develop new products and processes that meet sustainability standards while creating market differentiation and customer value (Horbach, 2008). These innovations can include biodegradable materials, energy-saving appliances, or modular product designs that facilitate disassembly and reuse. Economic sustainability also involves integrating sustainability into corporate risk

management, especially in light of increasing regulatory scrutiny, supply chain disruptions, and shifting consumer expectations (Eccles et al., 2012).

Transparency and accountability in financial and non-financial performance are supported through sustainability reporting frameworks such as the Global Reporting Initiative (GRI), the Carbon Disclosure Project (CDP), and Integrated Reporting (IR). These tools help companies communicate their sustainability impacts and progress to stakeholders, investors, and regulators, while fostering informed decision-making and continuous improvement (KPMG, 2020).

While environmental, social, and economic practices can be examined individually, their true value emerges when they are integrated into a coherent sustainability strategy (Stern & Valero, 2021). For instance, investment in energy-efficient technologies (an environmental practice) can lead to significant cost savings (an economic benefit), while also reducing occupational hazards related to outdated machinery (a social gain). Similarly, strong community relationships can enhance brand loyalty and customer trust, contributing to both social cohesion and economic performance (Porter & Kramer, 2011).

Ultimately, the success of sustainability in manufacturing depends on how well firms align their operational goals with broader societal and ecological imperatives. As global challenges intensify and stakeholder expectations evolve, manufacturers that effectively integrate environmental, social, and economic practices into their business models are more likely to achieve long-term resilience, innovation, and legitimacy in a rapidly changing industrial landscape.

This study focuses on sustainability practices that are both relevant to the aluminum rolling industry and measurable through employee perceptions and company operations. Specifically, the following practices are examined: a) environmental: energy-saving initiatives, waste recycling programs, water conservation efforts, and reduction of carbon emissions, b) social: promotion of occupational health and safety, employee training and development in sustainability, community engagement, and ethical labor practices, c) economic: investment in sustainable technologies, tracking financial benefits from sustainability initiatives, and maintaining a balance between profitability and long-term sustainability goals. These practices were selected because they reflect the core sustainability concerns in aluminum processing—particularly in rolling operations, which

are energy-intensive and labor-driven. They are also aligned with the Triple Bottom Line framework adopted in this research and are reflected in existing international standards such as the GRI and UN SDGs. Furthermore, these practices are measurable through the survey instrument designed for this study, enabling meaningful analysis of their impact on business performance.

2.4 Challenges in Sustainable Aluminum Production

The aluminum industry plays a critical role in global manufacturing and infrastructure, offering a lightweight, durable, and recyclable material widely used in sectors such as construction, transportation, packaging, and electronics (USGS, 2021). While aluminum is often lauded for its recyclability and contribution to energy efficiency in end-use applications—particularly in automotive and aerospace sectors—it presents significant sustainability challenges during its production and processing stages. These challenges are rooted in the industry's high energy intensity, environmental footprint, and complex supply chains (Reinsch & Benson, 2022; USGS, 2021).

One of the most prominent environmental challenges in aluminum production is the high energy consumption associated with the smelting process (Brough & Jouhara, 2020). Primary aluminum production via the Hall–Héroult process requires large amounts of electricity—often generated from fossil fuels—which contributes to substantial greenhouse gas (GHG) emissions. The International Energy Agency (IEA, 2020) estimates that aluminum production accounts for approximately 2% of global CO₂ emissions. In countries where electricity is predominantly coal-based, the carbon intensity of primary aluminum can be particularly high, exacerbating its environmental impact and complicating efforts to decarbonize the sector (Brough & Jouhara, 2020).

In addition to carbon emissions, the aluminum industry generates several environmentally hazardous by-products. The Bayer process, used for refining bauxite into alumina (the precursor to aluminum), produces large quantities of red mud, a highly alkaline waste material that poses risks to soil and water systems if not managed properly (Kirwan et al., 2013). Other by-products such as fluoride compounds and spent pot lining from smelters are also toxic and require specialized treatment and disposal. The management of these industrial wastes remains a persistent challenge, particularly in regions with weak

environmental regulations or inadequate waste infrastructure (Du et al., 2024; Harmaji, Jafari & Simard, 2024).

Resource extraction represents another significant sustainability concern. Bauxite mining, the first step in the aluminum value chain, is often associated with deforestation, biodiversity loss, and disruption of local communities. Although environmental impact assessments (EIAs) and community consultation processes are increasingly mandated, enforcement and compliance vary widely between countries. Moreover, the expansion of bauxite mining into ecologically sensitive areas has raised serious concerns about irreversible environmental degradation and social injustice (Sonter et al., 2017).

Water usage in aluminum production also presents a sustainability issue, particularly in refining and cooling processes. The high volumes of water required, combined with the potential for chemical contamination, make effective water management critical. In water-scarce regions, this can lead to competition with other local uses and increased operational risk (Yellishetty et al., 2011).

Social challenges in aluminum production, though less often discussed, are equally important. Communities near mines or processing facilities may experience land use conflicts, displacement, and negative health effects from air and water pollution (Sonter et al., 2017). Workers in aluminum plants can face occupational hazards due to exposure to heat, particulates, and hazardous substances. Ensuring ethical labor practices, health and safety standards, and community engagement is thus central to achieving a truly sustainable aluminum industry (Hilson, 2012).

Economically, the aluminum industry is subject to volatile commodity prices, energy costs, and fluctuating global demand, which can undermine long-term investment in sustainability initiatives (World Economic Forum, 2023). Many firms face the dilemma of balancing short-term cost pressures with the need for capital-intensive sustainability upgrades, such as energy-efficient furnaces, carbon capture technologies, or closed-loop recycling systems. For small and medium-sized aluminum processors—such as rolling divisions—the cost and complexity of sustainability transitions can be even more daunting without adequate technical and financial support (World Economic Forum, 2023).

Despite these challenges, the aluminum industry also presents notable opportunities for improvement. The use of secondary aluminum (i.e., recycled aluminum) consumes up to

95% less energy than primary production and generates significantly lower emissions. However, increasing recycling rates requires better infrastructure, product design for disassembly, and more effective collection systems. In addition, emerging technologies—such as inert anode cells and electrification of thermal processes—offer promising pathways for reducing the industry's carbon footprint, though widespread adoption remains limited by cost and technical barriers (IAI, 2021).

In conclusion, the sustainability challenges facing aluminum production are multifaceted and deeply interlinked. They span environmental degradation, resource and energy use, social impacts, and economic constraints. Addressing these issues requires coordinated efforts across the value chain, from responsible mining practices to technological innovation in smelting and rolling, regulatory reforms, and the integration of sustainability into corporate strategy. Only through a holistic and systems-based approach can the aluminum industry transition toward a more sustainable future.

2.5 Sustainability in the Aluminum Industry

The aluminum industry occupies a paradoxical position in the global sustainability agenda. On one hand, aluminum is a strategic material in the transition to low-carbon economies, with its lightweight properties contributing to fuel efficiency in transportation, energy-efficient buildings, and renewable energy technologies such as solar panels and wind turbines. On the other hand, the primary production of aluminum is one of the most energy- and resource-intensive industrial processes, responsible for a notable share of global greenhouse gas (GHG) emissions, land degradation, and water pollution (IRENA, 2025; IEA, 2020).

Sustainability in the aluminum industry thus requires a life-cycle perspective that encompasses raw material extraction, production, use, and end-of-life management. This approach recognizes that while upstream processes like bauxite mining and alumina refining are environmentally intensive, downstream applications and recycling offer significant sustainability advantages (The Aluminum Association, 2022). Accordingly, many aluminum producers are reorienting their strategies to minimize environmental impacts at each stage while enhancing social responsibility and economic performance (The Aluminum Association, 2022; Paraskevas et al., 2016).

A central pillar of sustainability in the industry is the increasing reliance on secondary aluminum. Recycling aluminum requires only about 5% of the energy used in primary production and results in substantially fewer emissions (IAI, 2020). As a result, companies are investing heavily in closed-loop recycling systems, product take-back schemes, and the design of aluminum products that facilitate disassembly and material recovery. However, achieving high recycling rates depends on well-developed collection infrastructure, material purity standards, and consumer participation, which vary significantly by region (Bertram et al., 2009).

At the production level, companies are adopting best available technologies (BATs) to improve energy efficiency and reduce emissions (IAI, 2021). Smelters are transitioning toward the use of low-carbon electricity—particularly hydropower, which is already widely used in countries like Norway, Canada, and Iceland—and are exploring the use of inert anodes to replace carbon anodes, a shift that could eliminate direct CO₂ emissions from electrolysis (IAI, 2021). Similarly, improvements in casting and rolling technologies, process digitization, and thermal energy recovery are helping to reduce the environmental burden of midstream operations (IRENA, 2025).

Environmental management systems (EMS), often aligned with ISO 14001 standards, are widely implemented in the sector to monitor and control emissions, resource use, and waste generation (ASI, 2023). Companies are also expanding their sustainability reporting practices, disclosing performance metrics related to energy use, carbon intensity, water consumption, and hazardous waste through frameworks such as the Global Reporting Initiative (GRI), CDP, and the Aluminum Stewardship Initiative (ASI). The ASI, in particular, has established a robust certification system that promotes responsible production, sourcing, and stewardship of aluminum, encompassing environmental, social, and governance (ESG) principles across the supply chain (ASI, 2023).

On the social front, sustainability in the aluminum industry involves ensuring occupational health and safety, respecting labor rights, and fostering community engagement, particularly in mining regions where operations can disrupt local livelihoods and ecosystems (Hilson, 2012). Companies are increasingly expected to engage stakeholders in transparent dialogue, conduct social impact assessments, and contribute to local development through infrastructure, education, and employment initiatives (Hilson, 2012). The growing focus on

just transitions emphasizes the importance of equitable labor practices and fair economic opportunities as the industry decarbonizes.

Economically, sustainability is viewed not just as a compliance issue but as a strategic opportunity. Companies that demonstrate leadership in sustainable practices often enjoy enhanced brand reputation, reduced operational risks, improved access to green financing, and stronger relationships with environmentally conscious customers and investors (Eccles et al., 2012). Moreover, the integration of ESG criteria into investment decisions is influencing capital flows toward aluminum producers that can demonstrate credible climate strategies and responsible governance (Safarov & Hasanov, 2024).

Nevertheless, challenges persist. Many aluminum producers—especially in developing countries—still rely on fossil-fuel-intensive energy, lack robust environmental enforcement, or operate under cost pressures that limit investment in clean technologies. In addition, while sustainability reporting is growing, there is still variability in the depth, accuracy, and comparability of data, which can obscure genuine progress and complicate stakeholder assessment (KPMG, 2020).

In conclusion, sustainability in the aluminum industry is both a challenge and a necessity. It demands systemic transformation across operations, supply chains, and product lifecycles. While substantial progress has been made in areas such as recycling, energy efficiency, and stakeholder engagement, further innovation, policy support, and cross-sector collaboration will be essential to align the industry with global climate goals and sustainable development targets.

2.6 Sustainability and Business Performance

In recent years, the relationship between sustainability and business performance has evolved from one of perceived trade-offs to one of strategic alignment. While early debates framed sustainability as a cost center or ethical obligation detached from economic returns, a growing body of research demonstrates that integrating environmental, social, and governance (ESG) principles into core business operations can enhance both financial performance and long-term organizational resilience (Eccles et al., 2012; Clark et al., 2015). As such, sustainability is no longer viewed as an optional or philanthropic endeavor, but as a value-creating approach that can generate competitive advantage.

From an environmental perspective, firms that proactively manage their ecological footprint often experience cost reductions through improved resource efficiency, waste minimization, and energy conservation. Sustainable practices such as lean manufacturing, circular resource flows, and the adoption of cleaner technologies reduce operational inputs and externalities, translating directly into lower production costs and reduced exposure to environmental regulation or carbon pricing (Porter & van der Linde, 1995). Moreover, companies that address climate risks through decarbonization strategies may also gain access to emerging green markets and qualify for sustainability-linked loans and investment opportunities.

The social dimension of sustainability also contributes significantly to business performance. Companies that invest in employee well-being, fair labor practices, and workplace safety tend to benefit from higher levels of worker satisfaction, engagement, and productivity (Jabbour et al., 2010). These improvements can lead to reduced turnover, improved innovation capacity, and stronger internal culture. Furthermore, socially responsible firms are better positioned to attract and retain talent, particularly among younger professionals who prioritize purpose-driven employment (Cone Communications, 2017). Engagement with communities and stakeholders can also build trust, reduce conflict, and strengthen the company's "social license to operate," a particularly important asset in resource-intensive or locally embedded industries (Gunningham et al., 2004).

From a financial and strategic standpoint, sustainability initiatives are increasingly correlated with superior market and stock performance. Firms with strong ESG practices often exhibit greater risk management, stronger reputations, and better preparedness for regulatory shifts and environmental shocks (Friede et al., 2015). For investors, these attributes are signals of long-term stability and governance quality. Several empirical studies have confirmed that companies with comprehensive sustainability strategies outperform peers in both accounting-based measures (e.g., return on assets, return on equity) and market-based metrics (e.g., Tobin's Q, stock returns) (Eccles et al., 2014). Moreover, sustainability performance is increasingly used as a proxy for corporate resilience, especially in the face of systemic disruptions such as climate change, pandemics, and geopolitical risks.

An important mechanism through which sustainability impacts business performance is innovation. Sustainability challenges often serve as catalysts for product, process, or business model innovation. Companies developing eco-efficient technologies, sustainable

packaging, or low-impact production processes are more likely to enter new markets and differentiate their offerings. This not only enhances reputation but can generate premium pricing, improve customer loyalty, and open up licensing or partnership opportunities (Dangelico & Pujari, 2010).

That said, the relationship between sustainability and business performance is not universally linear or automatic. The effectiveness of sustainability initiatives depends on how well they are aligned with the firm's core strategy, organizational culture, and operational capabilities. Superficial or symbolic adoption—often referred to as “greenwashing”—can erode stakeholder trust and generate reputational risk (Delmas & Burbano, 2011). Additionally, sustainability transitions often involve significant short-term costs—such as capital investment, process redesign, or training—which may not deliver immediate returns. Therefore, a long-term strategic orientation, senior leadership commitment, and stakeholder engagement are critical to realizing the performance benefits of sustainability.

Measurement and transparency also play a crucial role. Companies that systematically assess and communicate their sustainability performance using credible frameworks—such as the Global Reporting Initiative (GRI), Integrated Reporting (IR), and the Sustainability Accounting Standards Board (SASB)—are more likely to identify areas for improvement, track progress, and earn the confidence of investors and consumers (KPMG, 2020). ESG ratings and indexes further influence investor behavior, access to capital, and corporate valuation, reinforcing the financial materiality of non-financial performance.

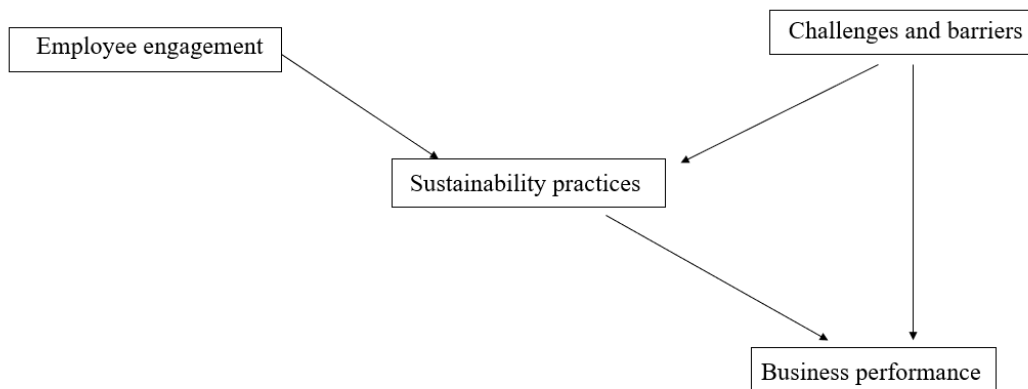
In conclusion, sustainability has become a core driver of business success in today's interconnected and environmentally constrained world. Far from being a constraint on profitability, it offers a pathway to innovation, efficiency, risk mitigation, and enhanced stakeholder value. For manufacturing firms in particular, where operations are closely tied to environmental and social systems, embedding sustainability into business strategy is not only ethically responsible but economically prudent.

2.7 Conceptual Framework and Research Gaps

This study adopts the Triple Bottom Line (TBL) framework developed by Elkington (1997) as the central conceptual lens to examine sustainability in the aluminum rolling sector. The TBL framework emphasizes three interrelated pillars of sustainability: environmental, social, and economic performance. These pillars are used to evaluate how sustainability practices are implemented within aluminum manufacturing operations and how they influence overall business performance. The conceptual framework posits that sustainability practices—when effectively implemented across environmental, social, and economic dimensions—positively influence business performance outcomes, such as operational efficiency, employee productivity, cost savings, brand reputation, and competitive advantage. In addition, internal factors such as employee awareness, leadership commitment, and organizational culture are recognized as key enablers or barriers that can mediate the effectiveness of these sustainability efforts. This framework provides a structured basis for developing the questionnaire, analyzing responses, and interpreting findings related to sustainability implementation and performance outcomes in the case study company (Graph 1).

The literature reveals several critical gaps that this study seeks to address. The first is the limited focus on midstream operations. Most existing sustainability studies in the aluminum industry concentrate on upstream (mining, smelting) or downstream (product application) stages. There is a lack of empirical research focusing on midstream activities, such as rolling operations, which are pivotal in shaping both production efficiency and environmental impact. The second research gap is the lack of empirical evidence on practice-performance linkages. While the benefits of sustainability are widely discussed, there is insufficient quantitative and employee-level data on how specific sustainability practices affect business performance metrics in aluminum manufacturing environments. The third gap is the underrepresentation of employee perspectives. Much of the current research adopts a top-down approach focused on company disclosures and managerial policies. This study addresses a gap by collecting data from employees at multiple levels to assess the depth of sustainability engagement and perceived outcomes. Also, few studies provide insights from Southern European or Greek aluminum companies, particularly within the rolling segment. This research contributes localized knowledge that reflects the unique regulatory, cultural,

and operational conditions of the region. By addressing these gaps, this study aims to provide a comprehensive, data-driven evaluation of sustainability practices and their business implications in the aluminum sector, with practical recommendations for both industry stakeholders and academic discourse.



Graph 1. Conceptual framework

3. Methodology

3.1 Research Design

Research design refers to the overall strategy and logical structure employed to integrate the various components of a study in a coherent and effective way. There are several types of research design available to researchers in the field of sustainability and business performance. The first type is the qualitative research. This approach is typically exploratory and is used to gain a deep understanding of underlying motivations, behaviors, and opinions. Common qualitative methods include interviews, focus groups, and case studies. While rich in detail, qualitative research is often limited in generalizability and is time-consuming (Creswell, 2014). Secondly, quantitative research relies on numerical data and statistical analysis to test hypotheses, identify patterns, and make generalizable conclusions. Common tools include structured questionnaires and experiments. Quantitative methods are particularly useful when dealing with large datasets and standardized indicators of performance (Bryman, 2016). Thirdly, combining qualitative and quantitative approaches, mixed methods enable researchers to capture both breadth and depth in data collection. While comprehensive, this design requires careful integration of data types and can be resource-intensive (Bryman, 2016).

This study employs a quantitative research design using a descriptive and correlational approach to investigate the implementation and impact of sustainability practices within an aluminum rolling division. The research aims to identify the extent to which environmental, social, and economic sustainability practices are adopted and how these practices influence business performance indicators such as cost savings, employee productivity, and competitiveness.

Quantitative research is appropriate for studies aiming to test hypotheses, assess relationships among variables, and produce generalizable findings (Creswell, 2014). It allows the researcher to measure variables such as employee awareness or sustainability performance in a structured and statistical way. Prior sustainability studies have widely used

quantitative surveys to investigate organizational practices and outcomes (e.g., Sarkis et al., 2011).

A cross-sectional survey methodology was selected as the most appropriate tool to collect primary data from employees across different departments and job levels within the selected company. This approach allows for the analysis of current practices and perceptions regarding sustainability and their perceived outcomes at a specific point in time. The cross-sectional design enables data collection at a single point in time across multiple aluminium companies, providing a snapshot of current practices and perceptions. This is especially effective in organizational research where immediate assessment of current implementation and performance is needed (Bryman, 2016). It has also been employed in similar sustainability assessments (e.g., Zailani et al., 2012).

The research design is based on the Triple Bottom Line (TBL) framework, which guided the development of the questionnaire and the categorization of sustainability indicators. The study focuses on the relationship between independent variables (sustainability practices: environmental, social, economic) and dependent variables (business performance outcomes), while also identifying key barriers and enablers of sustainability implementation. This framework is widely adopted in business sustainability research as it offers a holistic assessment of a company's performance beyond financial returns (Hubbard, 2009). It is particularly relevant in the aluminium sector, which faces pressures across all three dimensions due to its energy-intensive processes and environmental impact.

This design facilitates both descriptive analysis (e.g., frequency of specific sustainability practices, level of employee engagement) and inferential analysis (e.g., correlation between sustainability practices and performance metrics). It also enables the comparison of responses based on demographic variables such as job position, years of experience, and familiarity with sustainability concepts.

Employee awareness and engagement are critical to the successful implementation of sustainability strategies (Daily & Huang, 2001). By focusing on employees as respondents, this research captures operational insights and internal barriers that might not be visible

through top-level data alone. Prior studies (e.g., Yong & Mohd-Yusoff, 2016) emphasize the value of bottom-up data for evaluating sustainability integration within companies.

The quantitative approach was chosen due to its suitability for producing generalizable findings, enabling the identification of patterns, trends, and statistically significant relationships that can inform managerial decision-making and future research.

3.2 Sample

The sample for this study includes 60 employees working in various aluminum companies operating in Greece, primarily within the rolling and midstream processing sector. Participants were selected from companies of different sizes and organizational structures to ensure diverse representation of perspectives on sustainability practices. A non-probability purposive sampling method was employed, targeting individuals who are likely to have relevant knowledge or experience with environmental, social, or economic aspects of sustainability in their workplace. These include employees from departments such as production, quality control, environmental management, maintenance, health and safety, and administration. To capture a broad and inclusive dataset, the sample includes individuals from various job levels (e.g., operators, supervisors, managers) and experience brackets (from entry-level to senior employees). The chosen sampling strategy supports the study's goals of understanding both the implementation and the perceived impact of sustainability practices within the Greek aluminum sector, and allows for the identification of common challenges and best practices across the industry.

This non-probability method is widely used when specific knowledge, perspectives, or roles are needed to inform research questions (Palinkas et al., 2015). It allows the researcher to intentionally select individuals who are knowledgeable or involved in sustainability-related initiatives. Purposive sampling is especially effective in sustainability research, where understanding the depth of employee awareness, engagement, and perceived barriers is more important than general population-level inference (Etikan, Musa, & Alkassim, 2016). Employees at different operational levels bring varied insights into how sustainability practices are implemented in practice, as highlighted in past industry studies (Yong &

Mohd-Yusoff, 2016). Furthermore, selecting participants from multiple departments ensures a comprehensive view of the company's sustainability culture and implementation practices. This approach aligns with organizational research where internal diversity of perspective is critical (Patton, 2002).

3.3 Data Collection

The data collection for this study was conducted through a structured questionnaire, designed to assess the implementation of sustainability practices and their perceived impact on business performance within the aluminum sector. This method offers practical advantages such as speed, reach, cost-effectiveness, and standardization of responses. Structured questionnaires are widely used in sustainability and organizational research for gathering measurable data from large respondent groups (Bryman, 2016). The questionnaire was developed based on an extensive review of academic literature, with particular reference to sustainability management practices in manufacturing (Ghobakhloo, 2020; Dangelico & Pujari, 2010), and links between sustainability and business performance (Eccles et al., 2012; Porter & Kramer, 2011).

The instrument was structured into seven sections with approximately 35 questions, and used a combination of Likert-scale, multiple-choice, and closed-ended formats. This format is effective in sustainability research because it allows researchers to capture complex constructs like employee awareness or perceived barriers in a statistically analyzable format (Joshi et al., 2015). The aim was to collect both quantitative data on the frequency and nature of sustainability practices, and perceptual data on their impact. The questionnaire was designed to be completed within 10–15 minutes, ensuring ease of access for busy professionals.

The thematic structure of the questionnaire is as follows:

- Section 1 – Demographics: Captures general participant information including age, gender, job role, years of experience, and familiarity with sustainability principles.

- Section 2 – Environmental Sustainability: Assesses the adoption of environmental initiatives such as energy efficiency, recycling, water conservation, use of renewable energy, and emissions reduction.
- Section 3 – Social Sustainability: Focuses on workplace safety, employee well-being, training opportunities, ethical labor practices, and community engagement.
- Section 4 – Economic Sustainability: Evaluates investments in sustainable technologies, cost-efficiency, and alignment between sustainability and profitability.
- Section 5 – Challenges and Barriers: Identifies obstacles such as financial limitations, regulatory gaps, resistance to change, and lack of awareness.
- Section 6 – Business Performance: Investigates the relationship between sustainability practices and performance metrics such as cost savings, competitiveness, employee productivity, and customer satisfaction.
- Section 7 – Final Thoughts: Collects employees' views on the future of sustainability in their companies and their interest in further training.

3.4 Procedure

To gather primary data for this study, a structured questionnaire was administered using the online platform Google Forms. This method was selected due to its convenience, accessibility, and ability to reach participants across different companies and job roles within the aluminum sector in Greece. Google Forms was chosen due to its ease of use, compatibility with anonymous responses, and ability to collect data efficiently across geographically dispersed teams—an especially relevant feature for industrial settings like the aluminum sector (Wright, 2005). The questionnaire link was distributed via email and professional networks, targeting employees from various departments such as production, quality control, environmental management, and administration.

Participation in the study was entirely voluntary, and respondents were informed about the purpose and scope of the research prior to beginning the survey. An introductory statement at the beginning of the Google Form clarified that the study was conducted solely for academic purposes and assured participants that there were no personal or professional consequences for choosing not to participate or withdrawing at any point.

To ensure anonymity and confidentiality, no personally identifiable information (such as names, email addresses, or company names) was collected. Responses were stored securely and used exclusively for the purposes of statistical analysis and interpretation within the context of this thesis.

Before final deployment, the questionnaire was pre-tested with a small group of professionals in the aluminum sector to assess clarity, relevance, and completion time. Minor revisions were made based on feedback to improve question phrasing and ensure smooth comprehension. The final version of the questionnaire was estimated to take approximately 10–15 minutes to complete.

Data collection was conducted over a four-week period (in May 2025), during which reminders were periodically sent to encourage participation and maximize response rates. At the close of the survey period, responses were downloaded from Google Forms in Excel format and prepared for statistical analysis as described in Section 3.5.

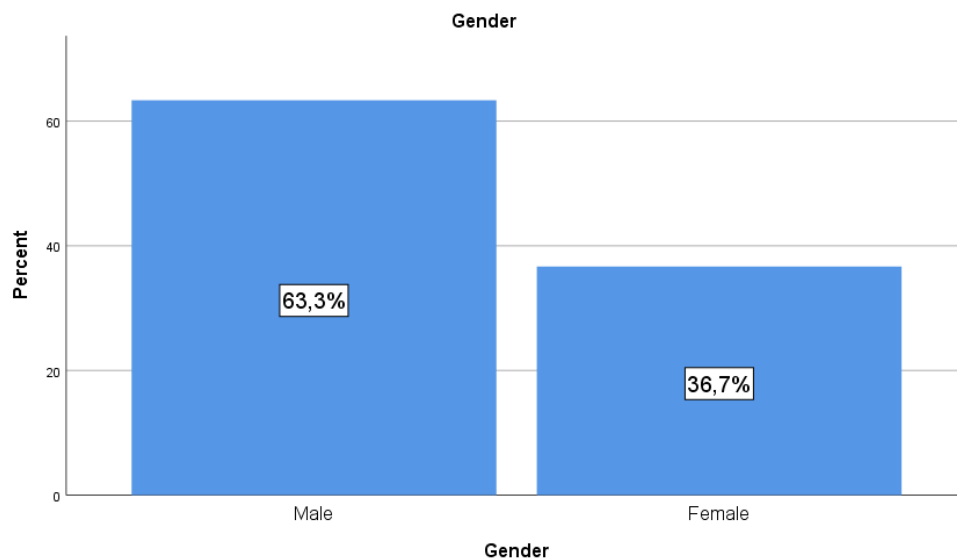
3.5 Statistical Analysis

The data collected through the online questionnaire were exported from Google Forms into Microsoft Excel and subsequently imported into IBM SPSS Statistics (Version 25) for statistical analysis. SPSS was selected for its robust capabilities in handling both descriptive and inferential statistics, making it well-suited for analyzing survey-based research. The analysis was conducted in two main stages. First, descriptive statistics were used to summarize the demographic characteristics of the respondents and to provide an overview of the frequency and distribution of responses across key survey variables. Measures such as frequencies and percentages, were calculated to identify trends and patterns in the adoption of environmental, social, and economic sustainability practices within the aluminum sector. To explore potential relationships between categorical variables, chi-square (χ^2) tests of independence were conducted. These tests were used to examine associations between sustainability practices and business performance indicators. All statistical analyses were performed using a significance level of $p < 0.05$, which was used as the threshold for determining statistical significance.

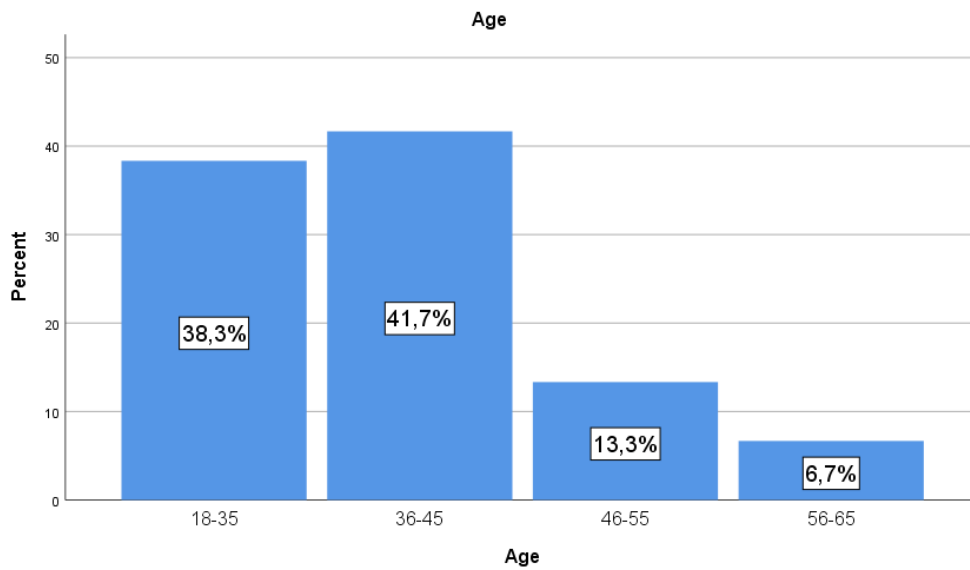
4. Results

4.1 Descriptive Statistics

The demographic profile of the respondents revealed that 63.3% (n=38) were male, while 36.7% (n=22) were female (Graph 2). Regarding age distribution, 38.3% (n=23) of participants were between 18 and 35 years old, 41.7% (n=25) were between 36 and 45 years old, 13.3% (n=8) were aged 46 to 55, and 6.7% (n=4) fell within the 56 to 65 age group (Graph 3).

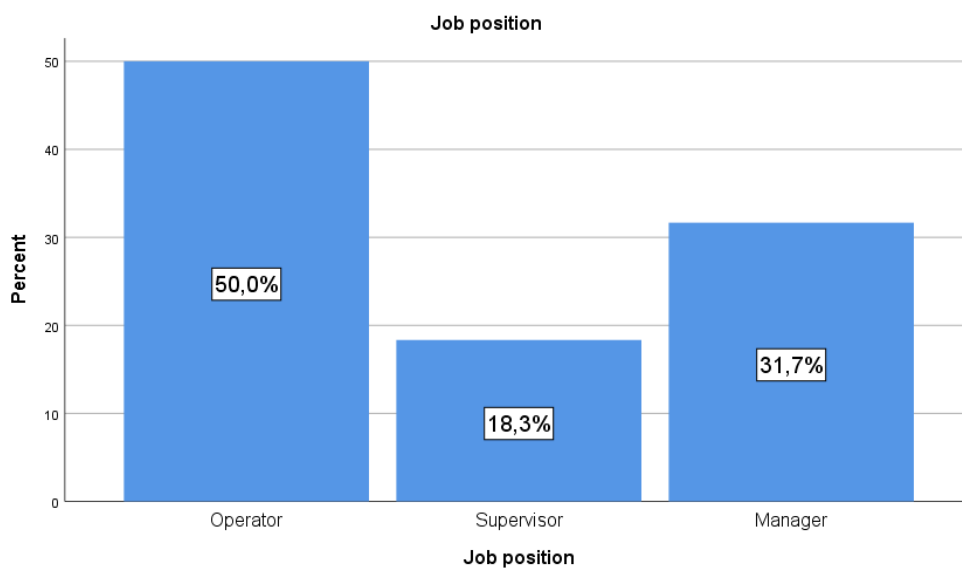


Graph 2. Gender

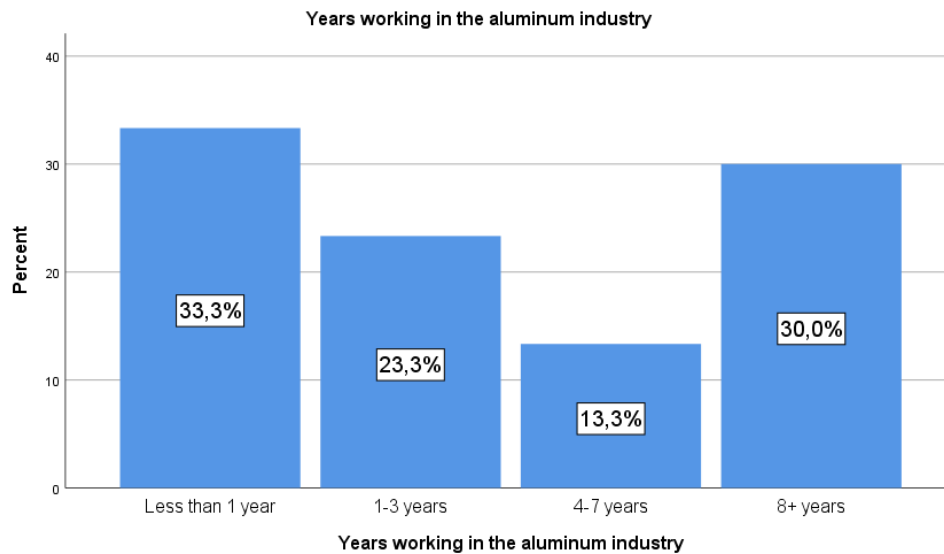


Graph 3. Age

In terms of occupational roles, 50.0% (n=30) of the respondents identified as operators, 18.3% (n=11) as supervisors, and 31.7% (n=19) as managers (Graph 4). With respect to experience in the aluminum industry, 33.3% (n=20) reported having less than one year of experience, 23.3% (n=14) had worked for one to three years, 13.3% (n=8) had between four and seven years of experience, and 30.0% (n=18) had over eight years of professional involvement in the sector (Graph 5).

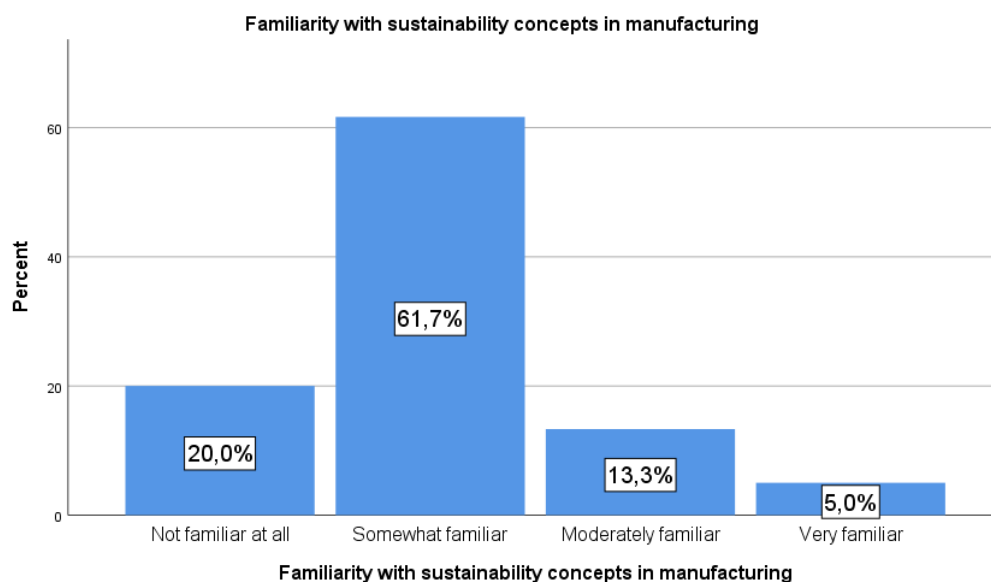


Graph 4. Job position



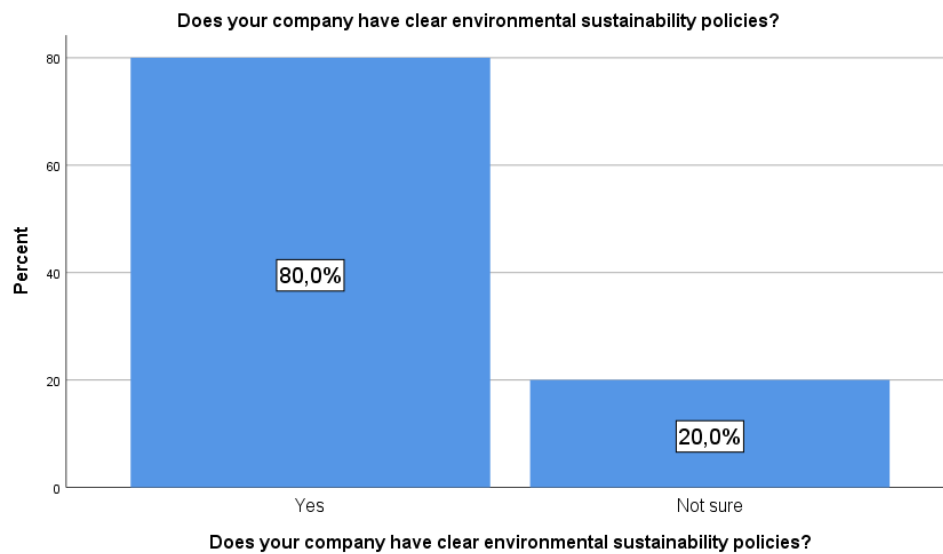
Graph 5. Years working in the aluminum industry

Participants were also asked to indicate their familiarity with sustainability concepts in manufacturing. Among them, 20.0% (n=12) stated they were not familiar at all, 61.7% (n=37) were somewhat familiar, 13.3% (n=8) reported moderate familiarity, and 5.0% (n=3) considered themselves very familiar with the topic (Graph 6).

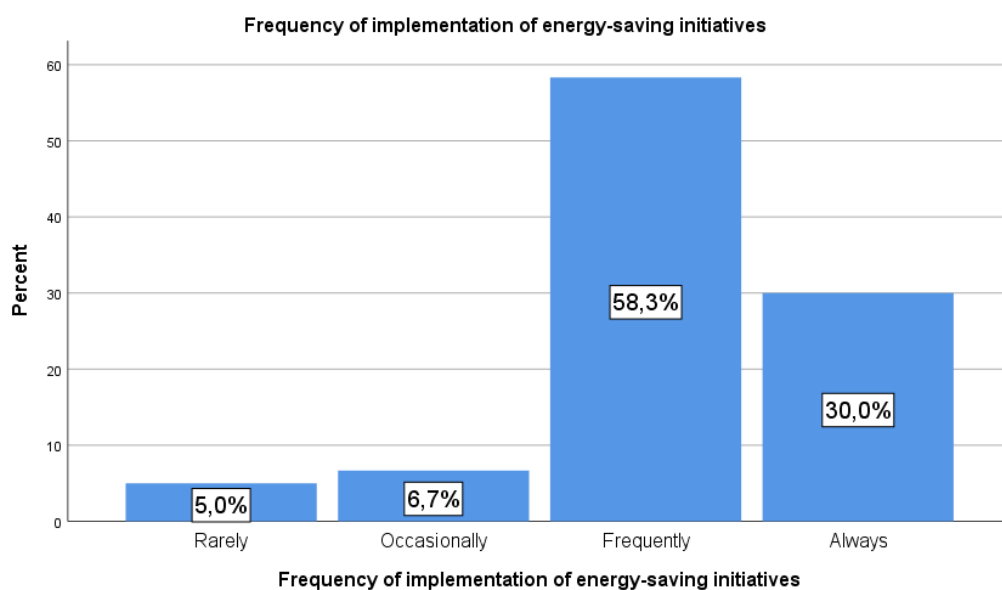


Graph 6. Familiarity with sustainability concepts in manufacturing

With regard to environmental sustainability policies, 80.0% (n=48) of respondents affirmed that their company maintains clear environmental sustainability policies, while 20.0% (n=12) were uncertain (Graph 7). Concerning the frequency of energy-saving initiatives, 5.0% (n=3) reported that such initiatives are implemented rarely, 6.7% (n=4) indicated occasional implementation, 58.3% (n=35) noted that they occur frequently, and 30.0% (n=18) stated that they are always applied (Graph 8).

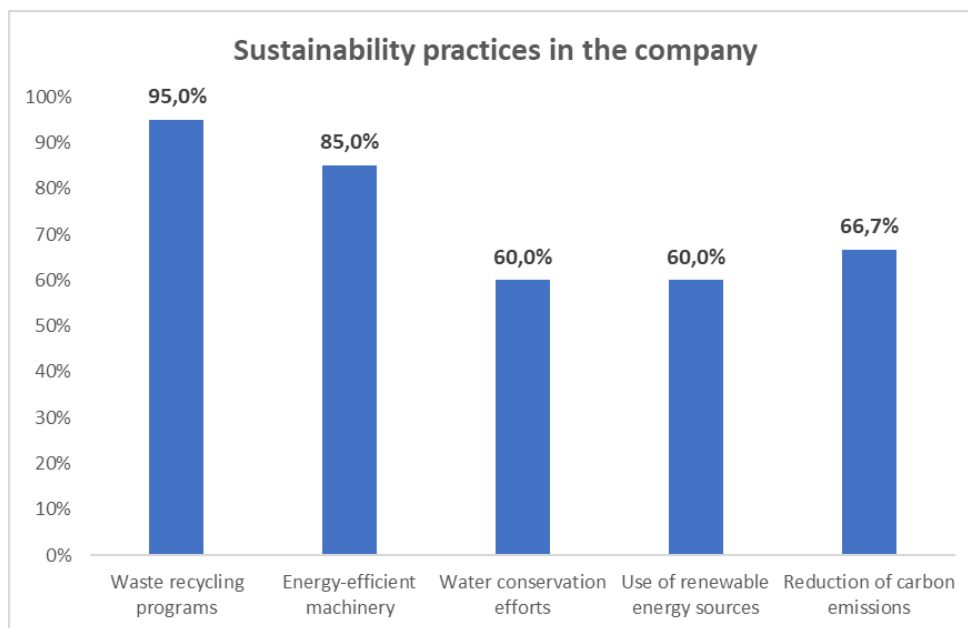


Graph 7. Clear environmental sustainability policies



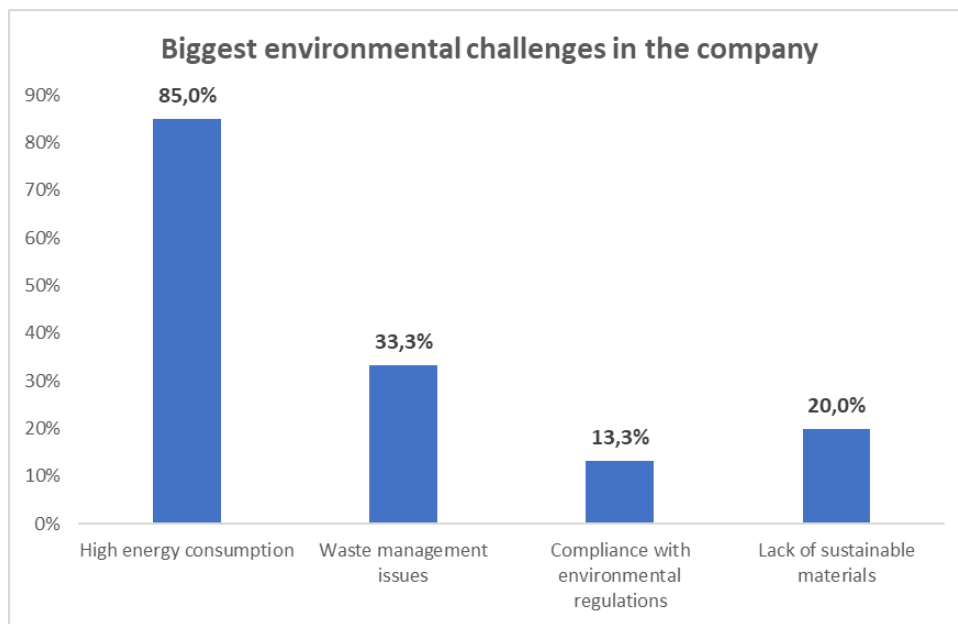
Graph 8. Frequency of implementation of energy-saving initiatives

Respondents were also asked to report on the presence of specific sustainability practices in their workplaces. Waste recycling programs were indicated by 95.0% (n=57) of participants, and the use of energy-efficient machinery was reported by 85.0% (n=51). Furthermore, 60.0% (n=36) reported the implementation of water conservation efforts, while an equal proportion (60.0%, n=36) noted the use of renewable energy sources. Additionally, 66.7% (n=40) stated that their companies are engaged in efforts to reduce carbon emissions (Graph 9).



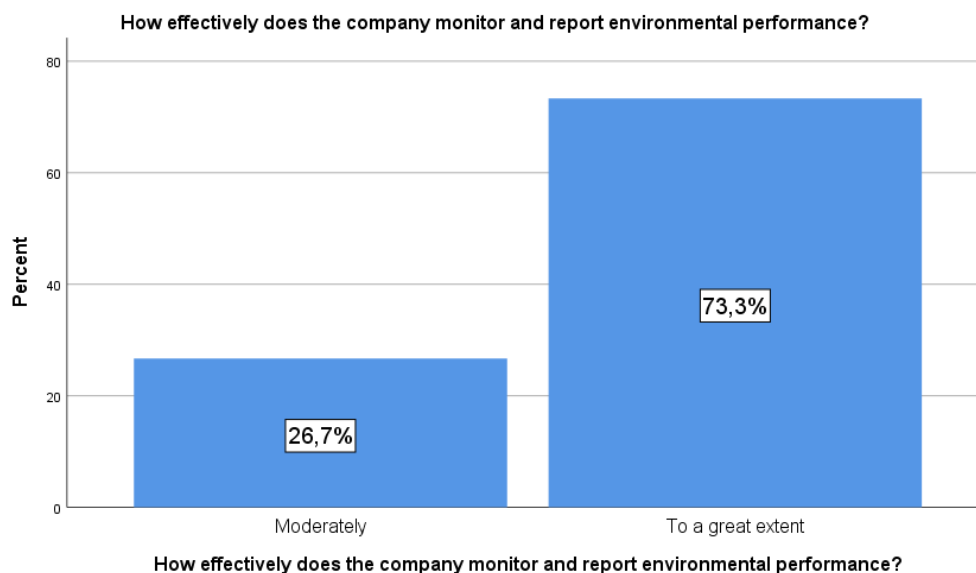
Graph 9. Sustainability practices in the company

In relation to perceived environmental challenges, 85.0% (n=51) of respondents identified high energy consumption as a major issue. Waste management challenges were reported by 33.3% (n=20), whereas 13.3% (n=8) mentioned compliance with environmental regulations as a concern. A lack of access to sustainable materials was cited by 20.0% (n=12) of the participants (Graph 10).



Graph 10. Biggest environmental challenged in the company

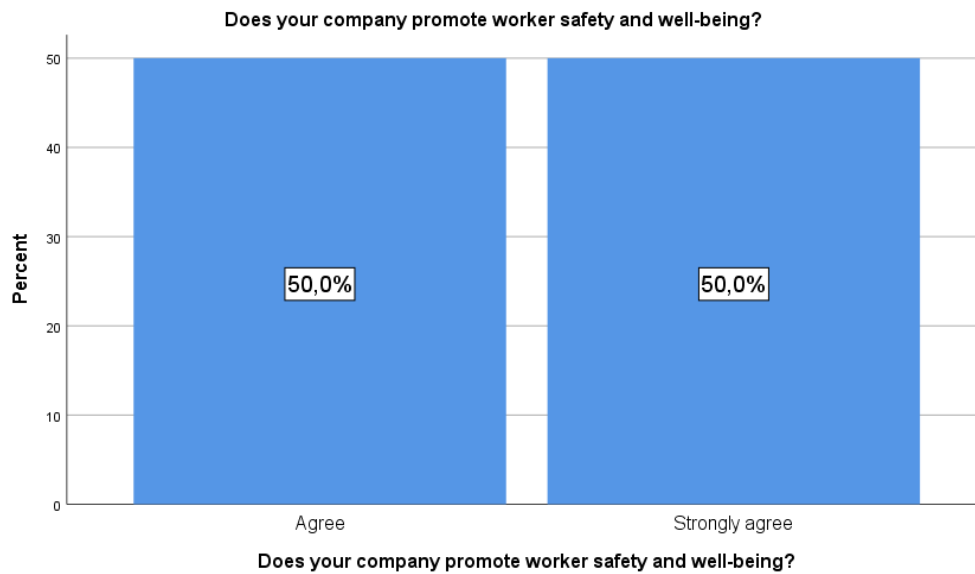
In terms of environmental performance monitoring, 26.7% (n=16) of participants indicated that their company monitors and reports environmental performance to a moderate extent, while 73.3% (n=44) reported that this is done to a great extent (Graph 11).



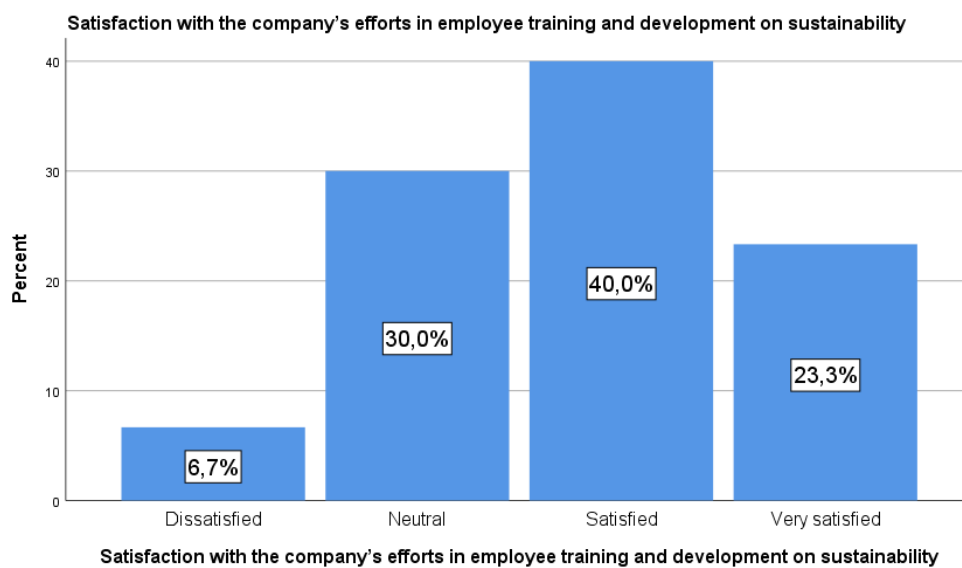
Graph 11. Efficiency of monitoring and reporting environmental performance

Regarding social sustainability, all respondents acknowledged that their company promotes worker safety and well-being, with 50.0% (n=30) agreeing and an equal 50.0% (n=30)

strongly agreeing with this statement (Graph 12). Concerning satisfaction with the company's efforts in employee training and development on sustainability, 6.7% (n=4) were dissatisfied, 30.0% (n=18) were neutral, 40.0% (n=24) were satisfied, and 23.3% (n=14) were very satisfied (Graph 13).

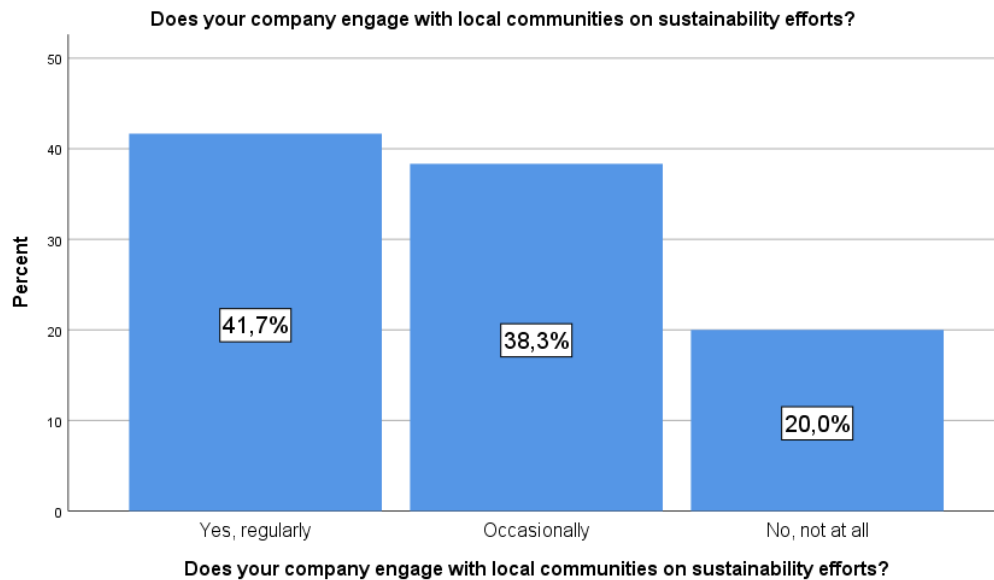


Graph 12. Promotion of work safety and well-being



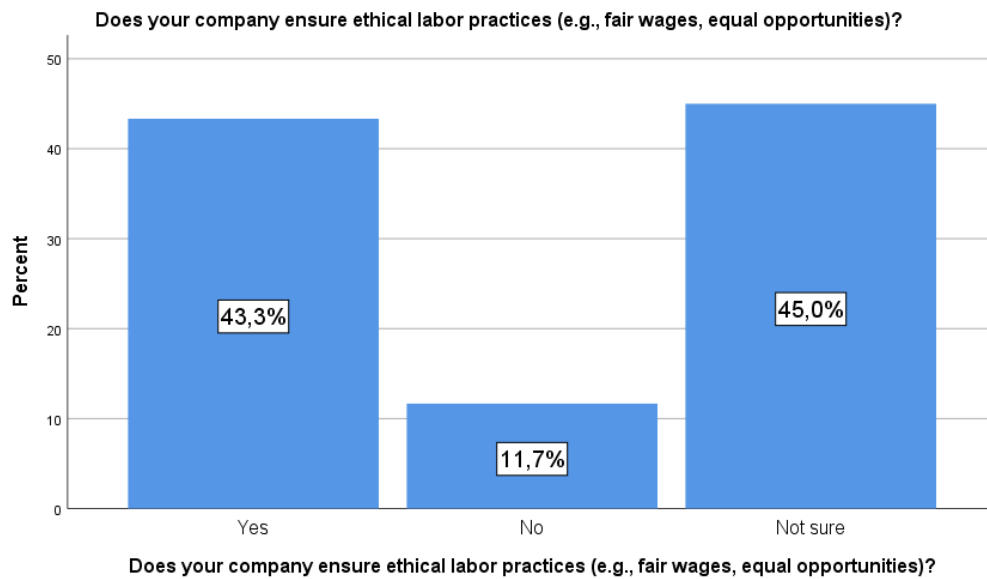
Graph 13. Satisfaction with company's efforts in employee training and development on sustainability

On the topic of community engagement, 41.7% (n=25) of respondents stated that their company regularly engages with local communities on sustainability efforts, 38.3% (n=23) reported occasional engagement, and 20.0% (n=12) indicated that their company does not engage with local communities at all (Graph 14).



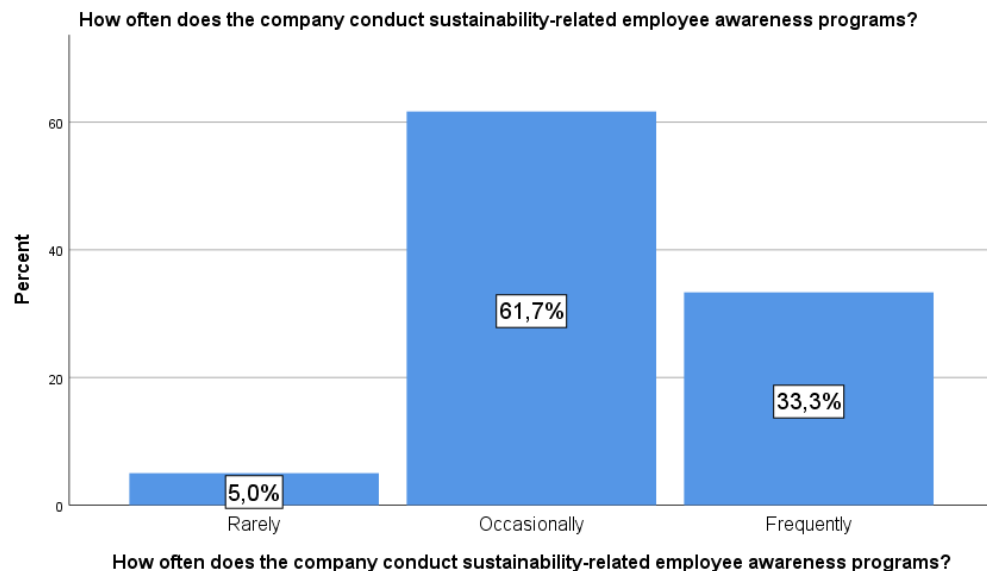
Graph 14. Engagement with local communities on sustainability efforts

With respect to ethical labor practices, 43.3% (n=26) of participants confirmed that their company ensures fair wages and equal opportunities, while 11.7% (n=7) disagreed. A notable 45.0% (n=27) were unsure about the existence of such practices within their organization (Graph 15).



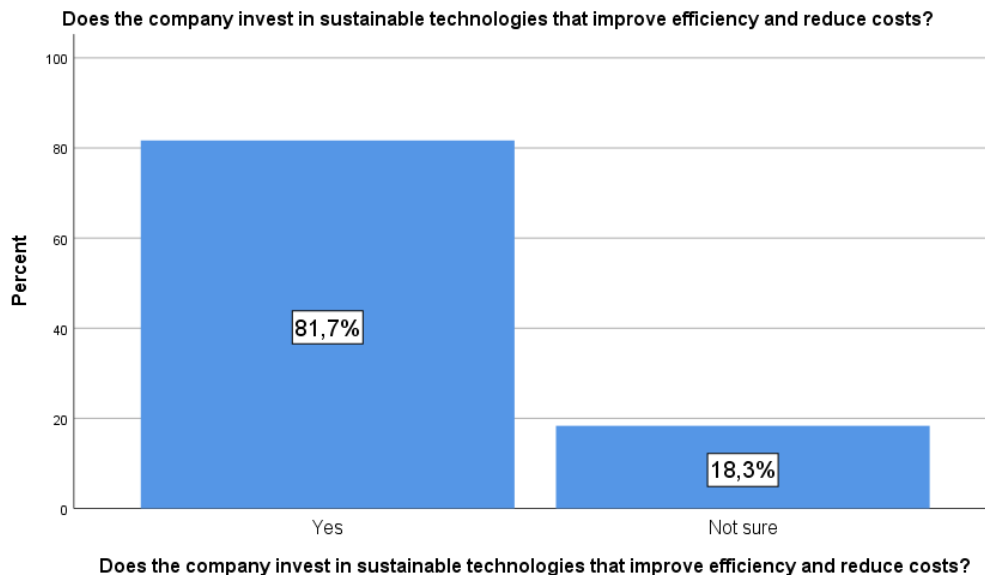
Graph 15. Ensuring ethical practices

When asked about the frequency of employee awareness programs related to sustainability, 5.0% (n=3) indicated that such programs are conducted rarely, 61.7% (n=37) stated they occur occasionally, and 33.3% (n=20) noted that they are conducted frequently (Graph 16).



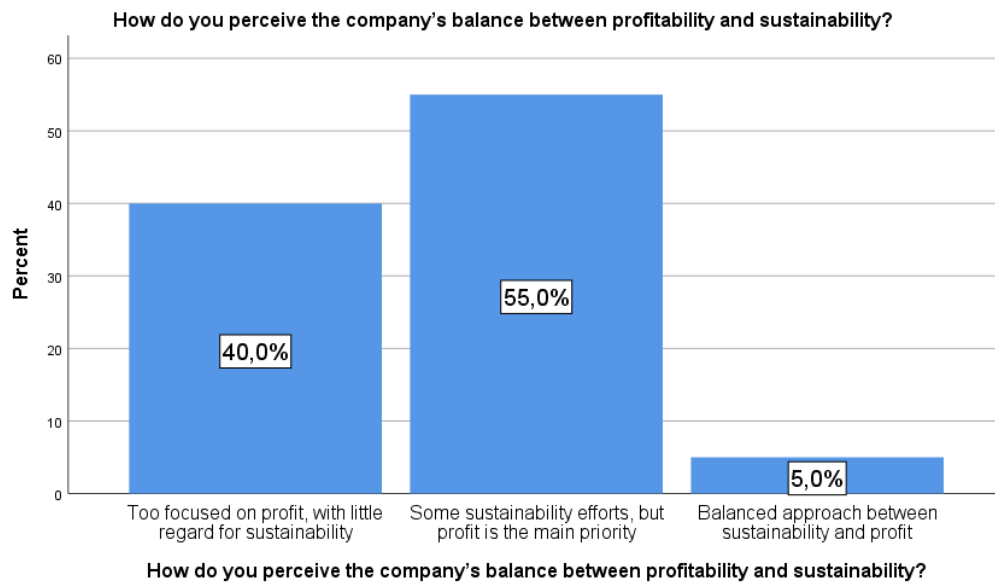
Graph 16. Frequency of conducting sustainability-related employee awareness programs

Turning to economic sustainability, 81.7% (n=49) of respondents affirmed that their company invests in sustainable technologies aimed at improving efficiency and reducing costs, while 18.3% (n=11) were uncertain (Graph 17).



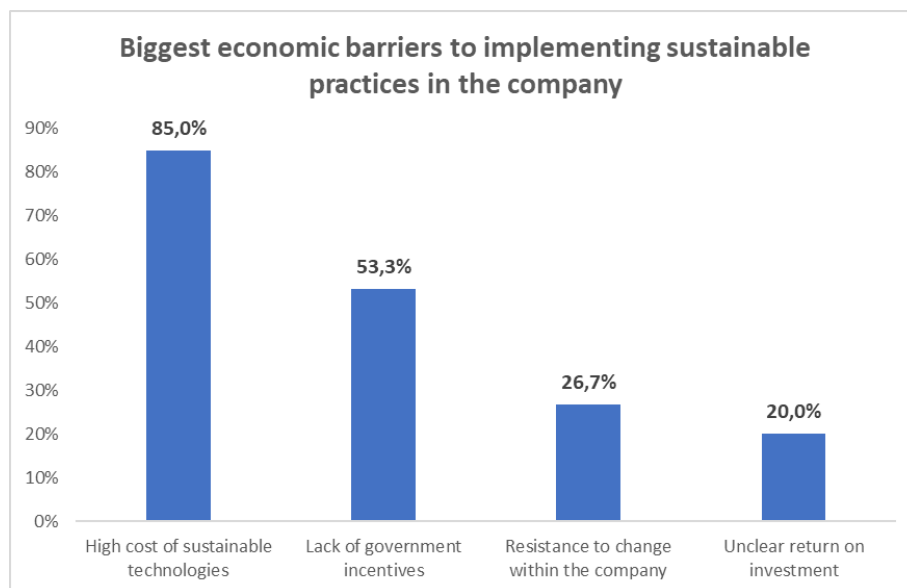
Graph 17. Investment in sustainable technologies

In relation to the perceived balance between profitability and sustainability, 40.0% (n=24) believed that the company is too focused on profit with little regard for sustainability, 55.0% (n=33) acknowledged some sustainability efforts but considered profit to be the main priority, and only 5.0% (n=3) perceived a balanced approach between profitability and sustainability (Graph 18).



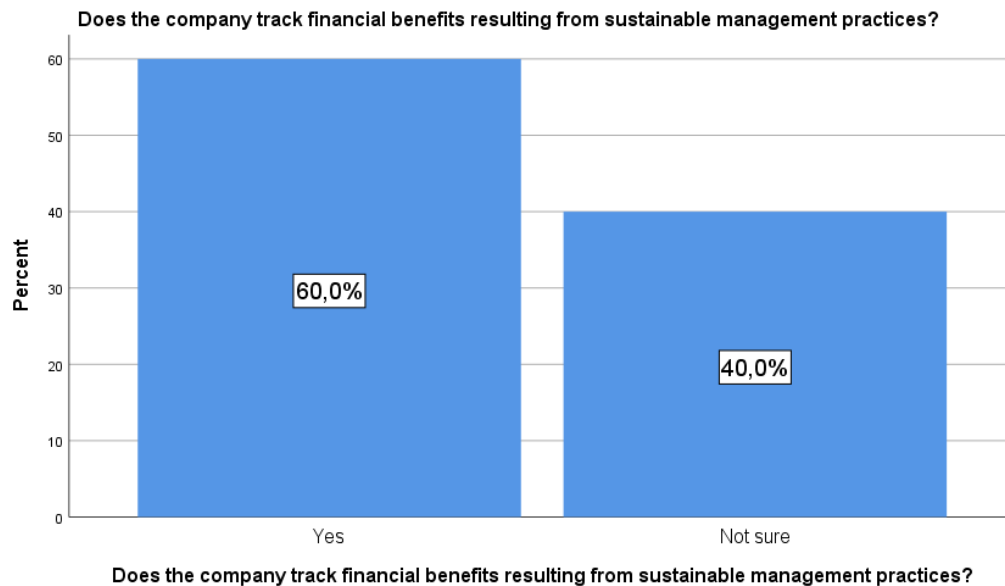
Graph 18. Company's balance between profitability and sustainability

Participants also identified the main economic barriers to the implementation of sustainable practices. The high cost of sustainable technologies was the most commonly cited barrier, reported by 85.0% (n=51) of respondents. Additionally, 53.3% (n=32) pointed to the lack of government incentives, 26.7% (n=16) mentioned resistance to change within the company, and 20.0% (n=12) indicated that an unclear return on investment was a significant obstacle (Graph 19).

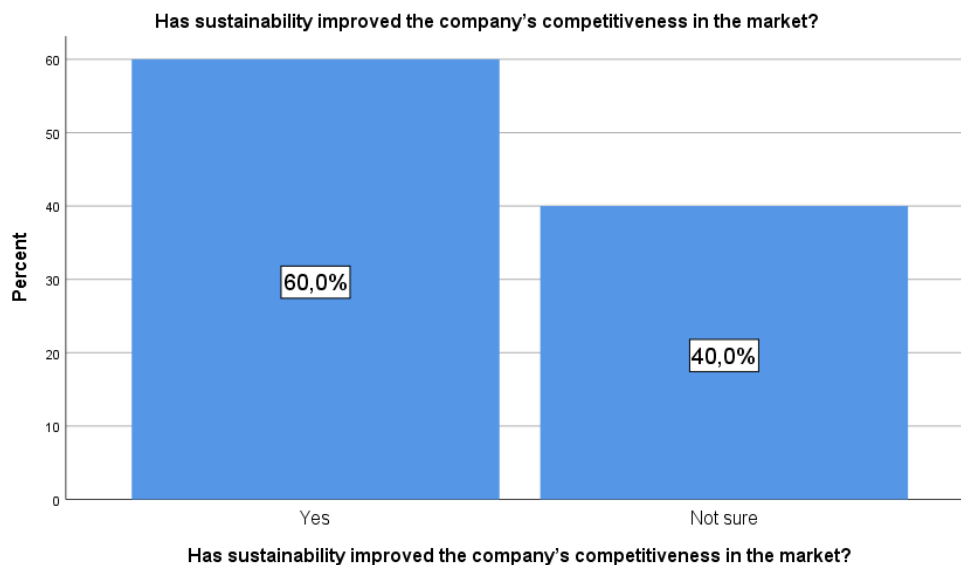


Graph 19. Biggest economic barriers to implementing sustainable practices in the company

With respect to the tracking of financial benefits arising from sustainable management practices, 60.0% (n=36) of participants confirmed that their companies monitor such outcomes, while 40.0% (n=24) were unsure (Graph 20). Similarly, 60.0% (n=36) indicated that sustainability efforts have improved their company's competitiveness in the market, whereas 40.0% (n=24) were not certain (Graph 21).

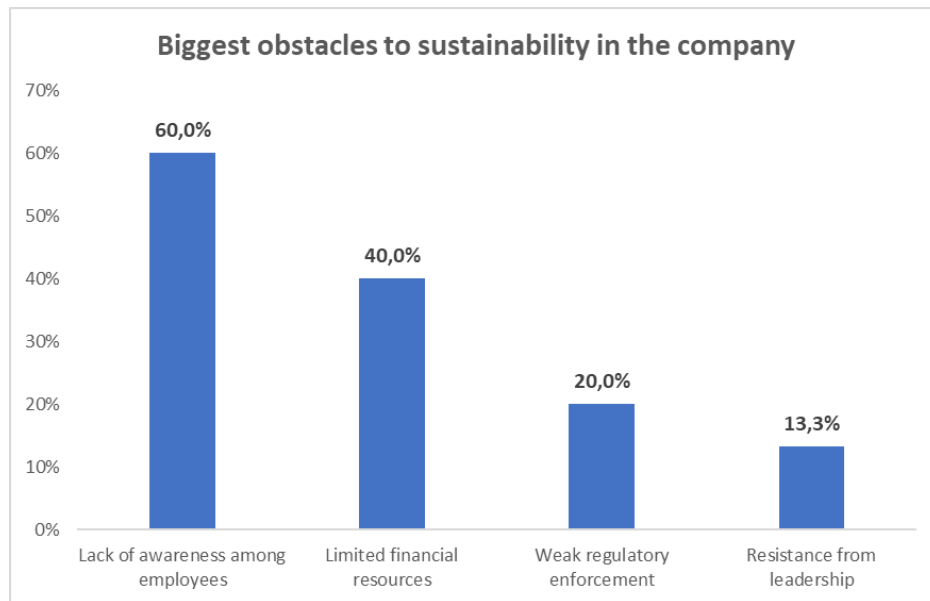


Graph 20. Tracking financial benefits resulting from sustainable management practices



Graph 21. Improvement of competitiveness in the market by sustainability

Participants were also asked to identify the most significant obstacles to sustainability within their organizations. A lack of awareness among employees was noted by 60.0% (n=36), limited financial resources by 40.0% (n=24), weak regulatory enforcement by 20.0% (n=12), and resistance from leadership by 13.3% (n=8) (Graph 22).



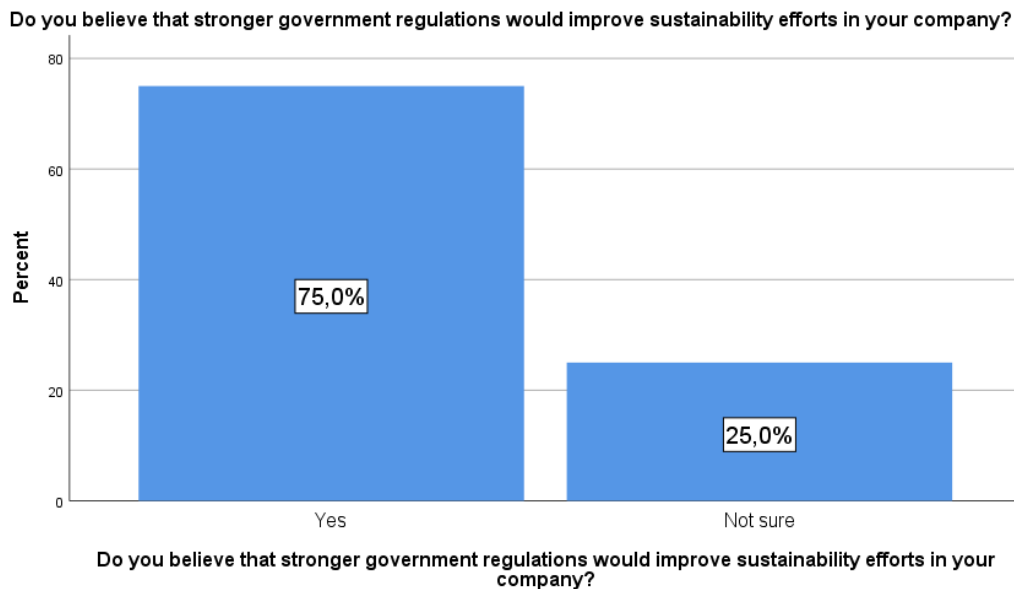
Graph 22. Biggest obstacles to sustainability in the company

Regarding organizational commitment to long-term sustainability goals, 6.7% (n=4) of respondents described their companies as somewhat committed, while 46.7% (n=28) assessed them as moderately committed, and another 46.7% (n=28) as strongly committed (Graph 23).



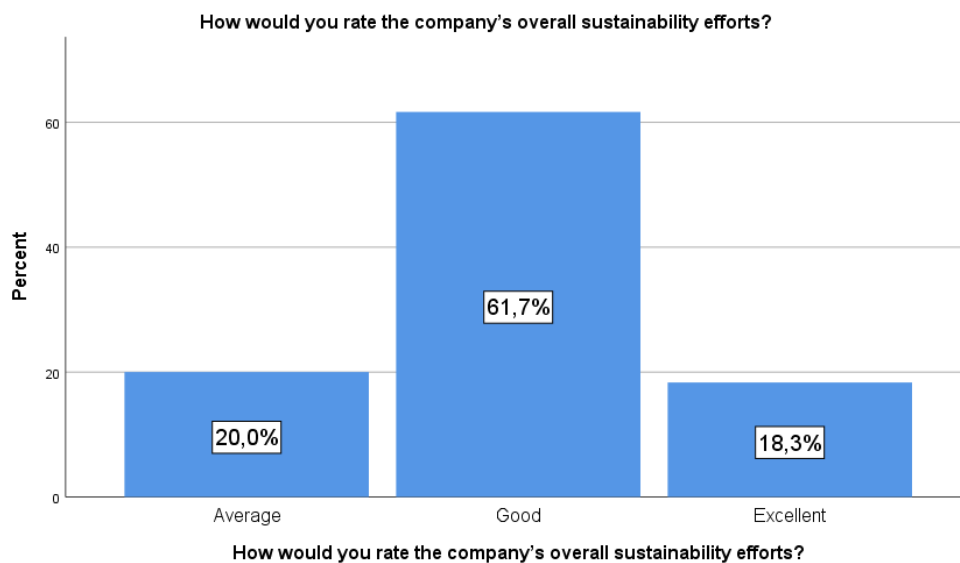
Graph 23. Commitment to long-term sustainability goals

In terms of external policy influence, 75.0% (n=45) of participants believed that stronger government regulations would enhance sustainability efforts in their company, whereas 25.0% (n=15) were uncertain (Graph 24).

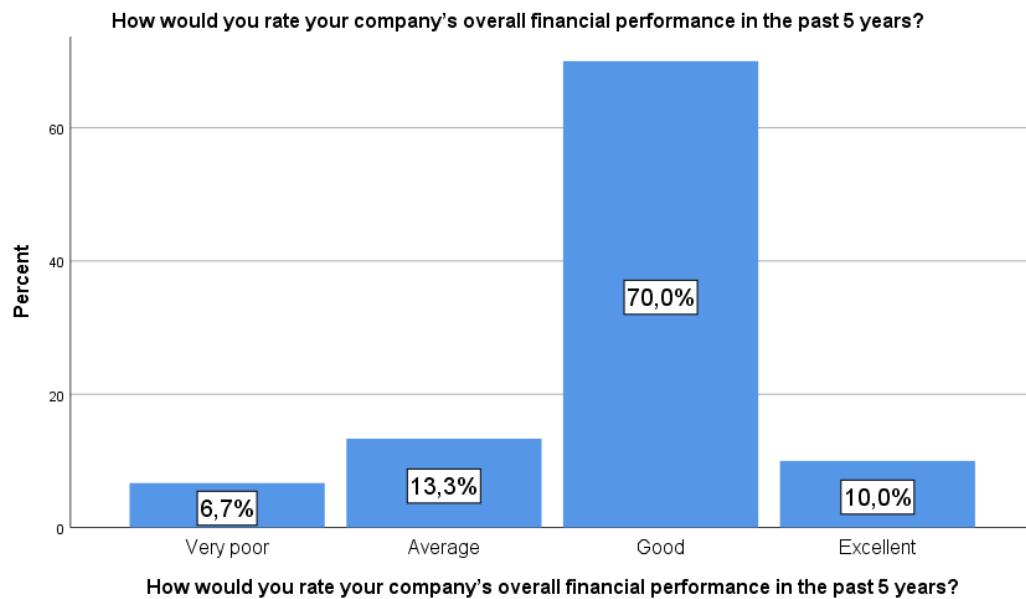


Graph 24. Importance of stronger regulations

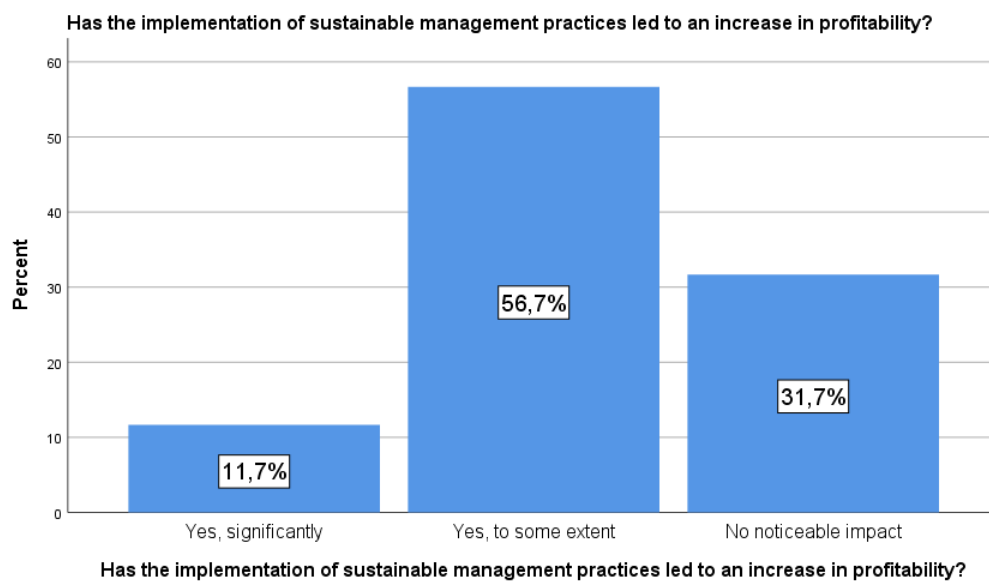
When asked to evaluate their company's overall sustainability efforts, 20.0% (n=12) rated them as average, 61.7% (n=37) as good, and 18.3% (n=11) as excellent (Graph 25). Regarding financial performance over the past five years, 6.7% (n=4) characterized it as very poor, 13.3% (n=8) as average, 70.0% (n=42) as good, and 10.0% (n=6) as excellent (Graph 26). Concerning the impact of sustainable management practices on profitability, 11.7% (n=7) of respondents reported a significant increase, 56.7% (n=34) observed some increase, and 31.7% (n=19) reported no noticeable impact (Graph 27).



Graph 25. Rating company's overall sustainability efforts



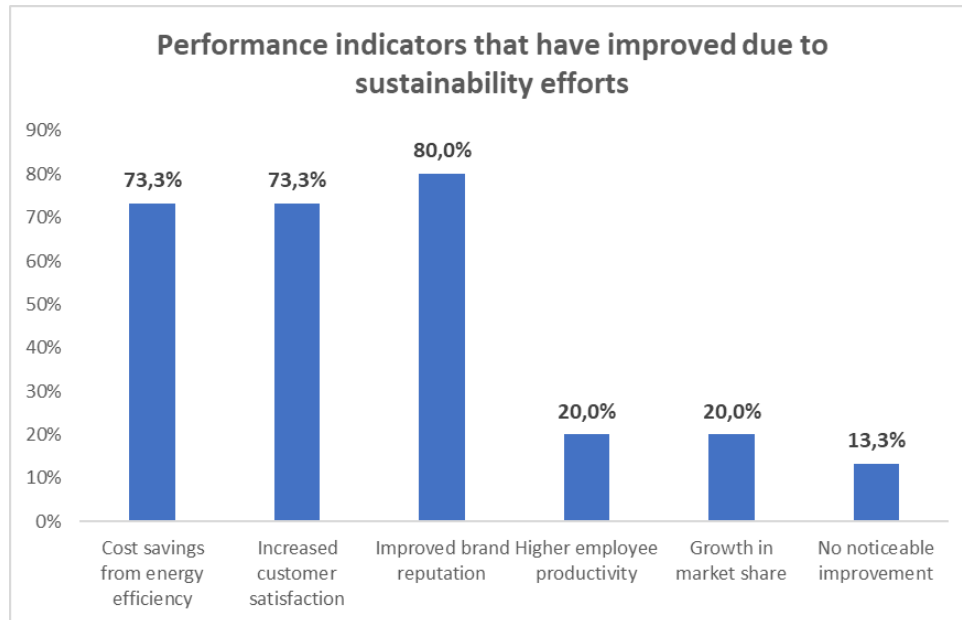
Graph 26. Rating company's overall financial performance in the past 5 years



Graph 27. Increase in profitability by sustainable management practices

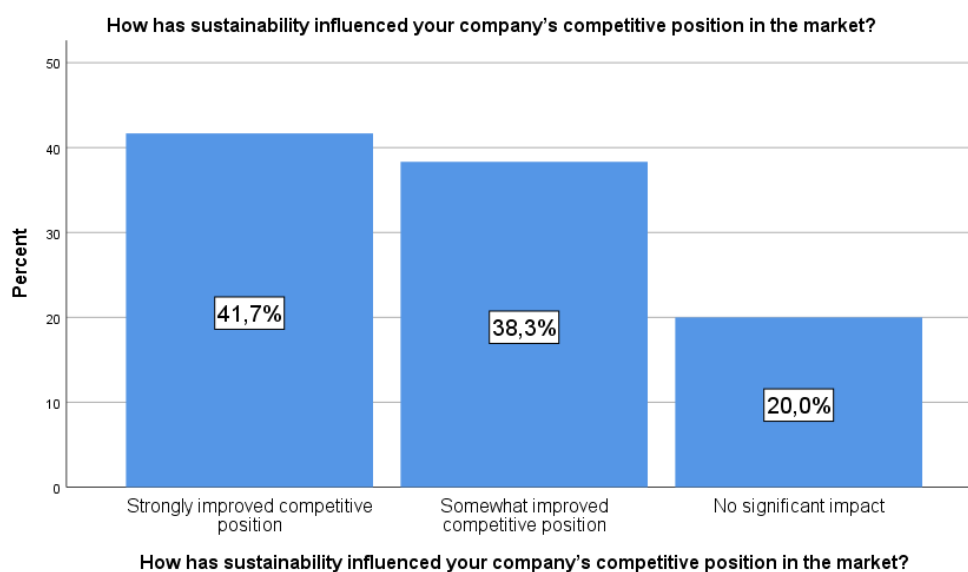
When asked about specific performance indicators improved through sustainability efforts, 73.3% (n=44) indicated cost savings from energy efficiency, and the same percentage (73.3%, n=44) cited increased customer satisfaction. Improved brand reputation was reported by 80.0% (n=48), while higher employee productivity and growth in market share

were each identified by 20.0% (n=12). Only 13.3% (n=8) stated that there had been no noticeable improvement in performance indicators (Graph 28).



Graph 28. Performance indicators that have improved due to sustainability efforts

In terms of competitiveness, 41.7% (n=25) of respondents felt that sustainability had strongly improved their company's competitive position, 38.3% (n=23) perceived a somewhat improved position, and 20.0% (n=12) indicated no significant impact (Graph 29).



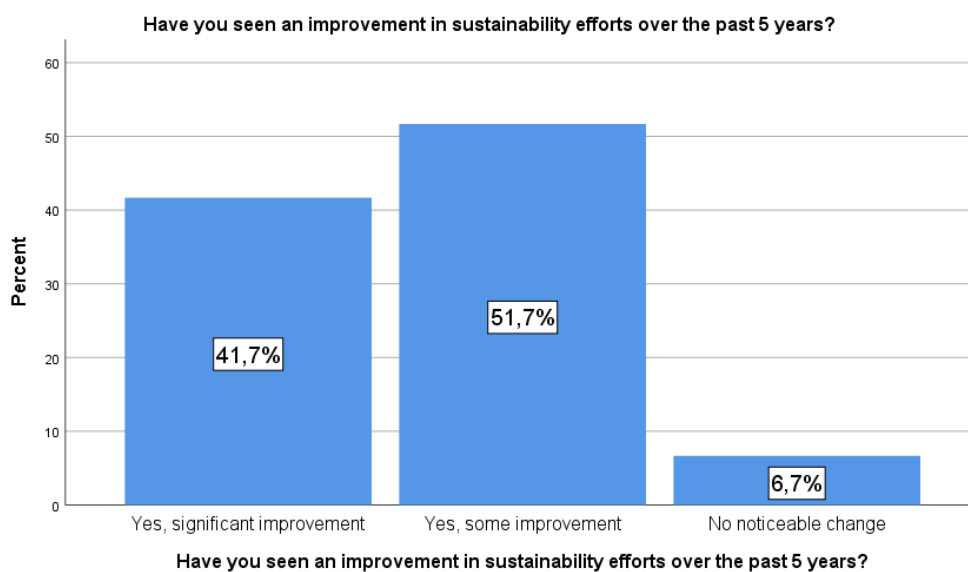
Graph 29. Influence of sustainability in competitive position in the market

Interest in further training on sustainability management was high, with 81.7% (n=49) expressing interest, 5.0% (n=3) indicating no interest, and 13.3% (n=8) responding "maybe" (Graph 30).



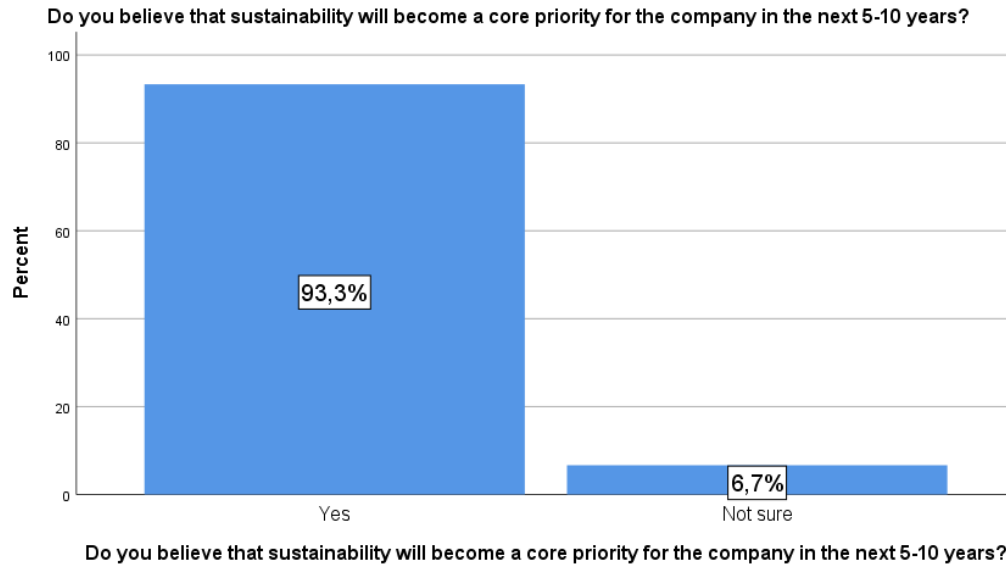
Graph 30. Interest in further training on sustainability management

Regarding perceptions of progress, 41.7% (n=25) observed significant improvements in sustainability efforts over the past five years, 51.7% (n=31) noticed some improvement, and 6.7% (n=4) reported no noticeable change (Graph 31).



Graph 31. Improvement in sustainability efforts over the past 5 years

Finally, 93.3% (n=56) of respondents believed that sustainability will become a core priority for their company in the next five to ten years, while 6.7% (n=4) were uncertain (Graph 32).



Graph 32. Sustainability as a core priority for the company in the next 5-10 years

4.2 Inductive Statistics

Chi-square tests were conducted to assess potential associations between selected sustainability-related practices and business performance indicators. The analysis revealed that none of the tested variables demonstrated a statistically significant correlation at the $p < .05$ level. Specifically, the presence of clear environmental sustainability policies was not significantly correlated with perceived improvements in market competitiveness ($p = .077$), commitment to sustainability goals ($p = .282$), overall financial performance ($p = .071$), increased profitability from sustainability ($p = .363$), or the company's competitive position ($p = .091$). Similarly, the frequency of implementation of energy-saving initiatives did not correlate significantly with competitiveness ($p = .061$), commitment to sustainability ($p = .184$), financial performance ($p = .181$), profitability ($p = .198$), or competitive position ($p = .474$). At the same time, the promotion of worker safety and well-being showed no statistically significant relationship with competitiveness ($p = .362$), sustainability commitment ($p = .657$), financial performance ($p = .467$), profitability ($p = .547$), or competitive positioning ($p = .522$). Ethical labor practices were also not significantly

associated with any of the business outcome variables, including competitiveness ($p = .367$), commitment ($p = .354$), financial performance ($p = .672$), profitability ($p = .892$), or market position ($p = .112$). Investment in sustainable technologies did not show a significant correlation with competitiveness ($p = .533$), sustainability commitment ($p = .139$), financial performance ($p = .063$), profitability ($p = .118$), or competitive position ($p = .380$). Lastly, respondents' evaluations of their company's overall sustainability efforts were not significantly correlated with perceived improvements in competitiveness ($p = .064$), commitment to sustainability ($p = .478$), financial performance ($p = .137$), profitability ($p = .692$), or competitive position ($p = .345$) (Table 1).

Table 1. Chi-square tests between sustainability-related practices and business performance indicators

	Does your company have clear environmental sustainability policies?	Frequency of implementation of energy-saving initiatives	Does your company promote worker safety and well-being?	Does your company ensure ethical labor practices (e.g., fair wages, equal opportunities)?	Does the company invest in sustainable technologies that improve efficiency and reduce costs?	How would you rate the company's overall sustainability efforts?
	p-value					
Has sustainability improved the company's competitiveness in the market?	,077	,061	,362	,367	,533	,064
How committed is your company to long-term sustainability goals?	,282	,184	,657	,354	,139	,478

How would you rate your company's overall financial performance in the past 5 years?	,071	,181	,467	,672	,063	,137
Has the implementation of sustainable management practices led to an increase in profitability?	,363	,198	,547	,892	,118	,692
How has sustainability influenced your company's competitive position in the market?	,091	,474	,522	,112	,380	,345

5. Discussion

5.1 Interpretation of Findings and Comparison with Previous Studies

The findings of this study offer important insights into how sustainability practices are understood, implemented, and experienced within the Greek aluminum sector, particularly in midstream operations such as rolling. The data gathered through the questionnaire reflect both encouraging progress in sustainability engagement and ongoing limitations in terms of integration, measurement, and perceived impact on business performance.

From an environmental standpoint, the majority of respondents reported the implementation of key sustainability practices, including waste recycling programs (95.0%), the use of energy-efficient machinery (85.0%), and consistent application of energy-saving initiatives (with 88.3% reporting frequent or constant implementation). These results align with global trends emphasizing energy efficiency and waste management in resource-intensive sectors (Ghobakhloo, 2020; IAI, 2021). Moreover, 60.0% of respondents indicated that their organizations apply water conservation efforts and use renewable energy sources, while 66.7% reported efforts to reduce carbon emissions. This reflects a growing awareness of environmental sustainability and suggests that many companies in the Greek aluminum sector are aligning their practices with international environmental standards such as ISO 14001 or the Global Reporting Initiative (GRI).

However, several challenges persist. High energy consumption was identified as the most significant environmental issue (85.0%), reinforcing existing literature on the energy-intensive nature of aluminum processing (Cullen & Allwood, 2013; Reinsch & Benson, 2022). Other barriers, such as a lack of sustainable materials (20.0%) and difficulties with regulatory compliance, suggest structural limitations that require both technological innovation and policy support. These findings are consistent with those of Hariram et al. (2023) and Hou et al. (2024), who argue that while environmental practices are being adopted, deeper systemic change is needed for long-term impact.

In terms of social sustainability, the results suggest a strong commitment to employee welfare. All participants agreed or strongly agreed that their company promotes worker safety and well-being—an encouraging sign in a sector where occupational hazards are

prevalent. Additionally, a significant portion of respondents expressed satisfaction with employee training and sustainability awareness programs. Engagement with local communities was also relatively high, with 41.7% reporting regular involvement and 38.3% reporting occasional engagement. These results echo the conclusions of Fernández-Muñiz et al. (2009) and Jabbour et al. (2010), who emphasized the role of safety, training, and community relations in building socially sustainable workplaces.

Nevertheless, there remains a degree of uncertainty regarding ethical labor practices, with 45.0% of respondents unsure whether their company ensures fair wages and equal opportunities. This ambiguity may reflect a communication gap within organizations or insufficient internal monitoring mechanisms. It underscores the point made by Lozano (2012) that sustainability must be embedded not only in external practices but also in the internal structures, cultures, and governance of firms.

Economic sustainability practices were also examined in depth. A large majority of respondents (81.7%) confirmed that their company invests in sustainable technologies to improve efficiency and reduce costs. Additionally, 60.0% indicated that their company tracks the financial benefits of sustainability initiatives, and 60.0% reported that sustainability had improved their company's competitiveness. Respondents perceived a number of specific business benefits from sustainability, including improved brand reputation (80.0%), cost savings (73.3%), and increased customer satisfaction (73.3%). These results are in line with prior studies, such as those by Eccles et al. (2012), Porter and van der Linde (1995), and Dangelico and Pujari (2010), who argue that sustainability can create value through efficiency gains, market differentiation, and stakeholder trust.

However, despite these positive perceptions, the statistical analysis did not yield significant associations between the adoption of sustainability practices and business performance outcomes. Chi-square tests indicated no significant correlations between variables such as the presence of environmental policies, investment in sustainable technologies, or employee safety programs and indicators like profitability, competitiveness, or financial performance. For example, while 56.7% of respondents believed that sustainable management practices had increased profitability to some extent, this relationship was not statistically supported ($p = 0.198$). Similarly, although 93.3% of respondents believed that sustainability would become a core company priority within 5–10 years, no variable was significantly associated with financial performance or market positioning.

These findings contrast with several influential studies (e.g., Clark et al., 2015; Friede et al., 2015) that identified positive, statistically significant relationships between sustainability performance and financial outcomes. One possible explanation for this discrepancy is the relatively short time frame in which sustainability initiatives have been implemented, which may limit the visibility of long-term impacts. Another contributing factor could be the modest sample size ($n = 60$), which restricts the statistical power of inferential analyses. Furthermore, the reliance on self-reported data may introduce perceptual bias, which can weaken the empirical relationship between practice and performance.

It is also important to consider contextual factors. The Greek industrial sector has faced numerous economic and regulatory challenges over the past decade, which may influence both the pace of sustainability adoption and the ability to realize business gains. As suggested by Setyaningsih et al. (2024), companies in small economies or in early stages of sustainability maturity often struggle with translating good intentions into measurable performance results. This study's findings support that assertion and emphasize the importance of time, strategy, and leadership in bridging the gap between sustainability implementation and business impact.

In conclusion, while the descriptive data reflect meaningful efforts toward sustainability in the aluminum sector and positive employee perceptions, the lack of statistically significant correlations indicates that further integration, measurement, and alignment of sustainability initiatives with core business functions are necessary. These results highlight the importance of organizational commitment, internal communication, and long-term planning—factors consistently emphasized in sustainability literature—as prerequisites for achieving both environmental and economic performance outcomes.

5.2 Limitations

Although this study contributes to the understanding of sustainability practices within the aluminum sector, several important aspects were not examined and therefore represent limitations of the research.

Firstly, the study did not include any objective performance data or financial metrics from company records. Business performance was assessed exclusively through employee

perceptions rather than through audited reports, operational KPIs, or environmental performance indicators (e.g., actual energy consumption, carbon emissions, cost savings). As a result, the findings provide insight into how employees perceive the effects of sustainability, but not whether these effects are reflected in measurable outcomes.

Secondly, the study focused only on midstream operations, particularly aluminum rolling, and did not explore the broader aluminum value chain. Upstream processes such as bauxite mining and smelting, and downstream activities such as product distribution and recycling, were outside the scope of this research. As a consequence, the study does not offer a full picture of sustainability challenges and practices across the entire industry lifecycle.

Third, the research did not examine the role of leadership, governance, or corporate strategy in sustainability implementation. While employee perspectives were valuable in assessing operational practices and awareness, the study did not investigate how sustainability is prioritized or managed at the strategic level, nor did it consider the influence of leadership commitment, organizational culture, or stakeholder engagement.

Additionally, the study did not assess the regulatory and policy environment in detail. Although lack of government incentives and weak enforcement were identified by participants as barriers, the research did not include a formal analysis of national environmental regulations, compliance mechanisms, or policy frameworks that influence sustainability in the Greek aluminum sector.

Finally, this research did not investigate the supplier or customer perspective in the sustainability process. Given the importance of sustainable supply chains and market-driven sustainability demands, the absence of insights from external stakeholders limits the study's scope to internal practices only.

6. Conclusions

6.1 Summary of Key Findings

This study examined the implementation of sustainability practices and their perceived impact on business performance in the Greek aluminum sector, with a specific focus on midstream operations such as aluminum rolling. Based on survey responses from 60 industry employees, several key findings emerged.

Firstly, the data indicate that a wide range of environmental sustainability practices are present across participating companies. These include high levels of engagement in waste recycling programs, the use of energy-efficient machinery, and the regular implementation of energy-saving initiatives. However, significant environmental challenges were also reported, particularly high energy consumption and limited access to sustainable materials.

Secondly, with regard to social sustainability, the findings suggest that worker safety and well-being are broadly promoted, and many employees are satisfied with sustainability-related training and community engagement. Nonetheless, uncertainty surrounding ethical labor practices, such as equal pay and non-discrimination, highlights potential gaps in communication or policy transparency.

In terms of economic sustainability, the majority of respondents reported that their companies invest in sustainable technologies and perceive some positive effects, such as cost savings, improved brand reputation, and increased customer satisfaction. At the same time, economic barriers—especially the high cost of sustainable technologies and insufficient government incentives—were identified as major obstacles to broader implementation.

Despite these encouraging trends in sustainability engagement, the statistical analysis revealed no significant correlations between sustainability practices and key business performance indicators such as profitability, competitiveness, and financial outcomes. While participants reported positive perceptions, the absence of statistically significant associations suggests that the impact of sustainability on performance may be complex, delayed, or influenced by unexamined variables.

Overall, the findings demonstrate a strong level of employee awareness and involvement in sustainability efforts, alongside recognized challenges and areas for further improvement. The results emphasize the need for deeper organizational integration of sustainability and more robust performance measurement systems to translate sustainable practices into measurable business outcomes.

6.2 Practical Implications

The findings of this study offer several practical implications for companies operating in the aluminum sector, particularly those seeking to integrate sustainability more effectively into their operations and strategic decision-making.

First, the high reported adoption of environmental practices such as energy-saving initiatives, recycling, and emissions reduction demonstrates that sustainability is already present at the operational level. However, companies should move beyond isolated initiatives and adopt a more systematic and strategic approach. This includes establishing formal sustainability frameworks, setting measurable goals, and linking sustainability objectives with overall business strategy. Integrating tools such as environmental management systems (e.g., ISO 14001) or sustainability reporting standards (e.g., GRI) can enhance accountability and performance monitoring.

Second, while employee perceptions of social sustainability were generally positive—especially in terms of safety and well-being—uncertainty regarding ethical labor practices suggests a need for clearer internal communication and stronger HR policies. Companies should ensure that equal opportunities, non-discrimination, and fair compensation policies are not only in place but also well-understood by all levels of the workforce. Regular training, employee engagement programs, and transparent reporting mechanisms can help address this gap.

Third, the study highlights the importance of economic incentives and support structures in advancing sustainability. Many respondents identified the high cost of sustainable technologies and the lack of government incentives as barriers. In response, companies should explore partnerships, subsidies, or participation in industry initiatives that can reduce financial burdens. Internally, firms can benefit from conducting cost-benefit analyses to

demonstrate the long-term economic value of sustainability investments, thereby building stronger business cases for future projects.

Moreover, the lack of statistically significant correlations between sustainability practices and business performance points to a need for improved performance measurement systems. Companies are encouraged to develop more sophisticated methods for tracking the impact of sustainability on profitability, productivity, customer satisfaction, and market competitiveness. This may involve closer collaboration between sustainability officers, financial analysts, and operational managers to align data collection and decision-making processes.

Finally, the strong employee interest in further training and the broad belief that sustainability will become a core priority in the near future indicate a positive organizational culture shift. Management should leverage this momentum by investing in continuous education and professional development in sustainability-related topics. Doing so can help build internal capacity, foster innovation, and support a smoother transition toward sustainable industrial practices.

6.3 Suggestions for Future Research

While this study provides meaningful insights into the sustainability practices of the aluminum sector in Greece, several areas remain underexplored and offer opportunities for future research.

First, future studies should consider incorporating objective performance data to complement employee perceptions. This may include energy usage metrics, carbon footprint measurements, production efficiency indicators, and financial performance figures. Access to such data would allow for more precise evaluation of the actual impact of sustainability practices on business outcomes and would strengthen the empirical foundation of the sustainability–performance relationship.

Second, longitudinal research designs are recommended to assess the effects of sustainability initiatives over time. Many environmental and economic benefits of sustainable practices may not be immediately visible, particularly in industries with long investment cycles such as aluminum production. Long-term studies would allow researchers

to track changes in performance, culture, and stakeholder engagement as sustainability becomes more deeply embedded in company operations.

Third, future research could broaden the focus to include other stages of the aluminum value chain, such as upstream mining and smelting, or downstream product development and recycling. This would offer a more holistic understanding of sustainability challenges and best practices across the industry and allow for comparative analyses between different operational phases.

In addition, there is a need to investigate the role of leadership, governance structures, and strategic orientation in the implementation of sustainability. This study concentrated primarily on employee perceptions at the operational level; however, sustainability is often driven or hindered by decisions made at the executive level. Future studies could examine how leadership commitment, corporate sustainability goals, and stakeholder engagement influence the success and integration of sustainability efforts.

Moreover, further research should explore the influence of external stakeholders, including suppliers, customers, investors, and regulators. Understanding how external expectations, market pressures, and policy frameworks shape corporate sustainability practices could provide deeper insights into the drivers and constraints of sustainability in the aluminum sector and beyond.

Finally, future studies could expand the geographical and sectoral scope, allowing for cross-national or cross-sector comparisons. Comparing findings from the Greek aluminum industry with those from other countries or heavy industries could help identify common patterns, contextual differences, and transferable best practices.

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Appendix A: Questionnaire

Section 1: Demographics

Gender

- ☐ Male
- ☐ Female

Age

- ☐ 18-35
- ☐ 36-45
- ☐ 46-55
- ☐ 56-65
- ☐ 66+

What is your job position?

- ☐ Operator
- ☐ Supervisor
- ☐ Manager
- ☐ Other (please specify): _____

How many years have you worked in the aluminum industry?

- ☐ Less than 1 year
- ☐ 1-3 years
- ☐ 4-7 years
- ☐ 8+ years

How familiar are you with sustainability concepts in manufacturing?

- ☐ Not familiar at all
- ☐ Somewhat familiar
- ☐ Moderately familiar

- ☐ Very familiar

Section 2: Environmental Sustainability

Does your company have clear environmental sustainability policies?

- ☐ Yes
☐ No
☐ Not sure

How often does your company implement energy-saving initiatives?

- ☐ Never
☐ Rarely
☐ Occasionally
☐ Frequently
☐ Always

Which of the following sustainability practices are present in your workplace? (Select all that apply)

- ☐ Waste recycling programs
☐ Energy-efficient machinery
☐ Water conservation efforts
☐ Use of renewable energy sources
☐ Reduction of carbon emissions

What are the biggest environmental challenges faced by your company? (Select all that apply)

- ☐ High energy consumption
☐ Waste management issues
☐ Compliance with environmental regulations
☐ Lack of sustainable materials
☐ Other (please specify): _____

How effectively does the company monitor and report environmental performance?

- ☐ Not at all
- ☐ To a small extent
- ☐ Moderately
- ☐ To a great extent

Section 3: Social Sustainability

Does your company promote worker safety and well-being?

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

How satisfied are you with the company's efforts in employee training and development on sustainability?

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neutral
- ☐ Satisfied
- ☐ Very satisfied

Does your company engage with local communities on sustainability efforts?

- ☐ Yes, regularly
- ☐ Occasionally
- ☐ No, not at all
- ☐ Not sure

Does your company ensure ethical labor practices (e.g., fair wages, equal opportunities)?

- ☐ Yes
- ☐ No

- ☐ Not sure

How often does the company conduct sustainability-related employee awareness programs?

- ☐ Never
☐ Rarely
☐ Occasionally
☐ Frequently

Section 4: Economic Sustainability

Does the company invest in sustainable technologies that improve efficiency and reduce costs?

- ☐ Yes
☐ No
☐ Not sure

How do you perceive the company's balance between profitability and sustainability?

- ☐ Too focused on profit, with little regard for sustainability
☐ Some sustainability efforts, but profit is the main priority
☐ Balanced approach between sustainability and profit
☐ Sustainability is a major focus, even at the cost of short-term profit

What do you think are the biggest economic barriers to implementing sustainable practices?

(Select all that apply)

- ☐ High costs of sustainable technologies
☐ Lack of government incentives
☐ Resistance to change within the company
☐ Unclear return on investment

Does the company track financial benefits resulting from sustainable management practices?

- ☐ Yes

- ☐ No
- ☐ Not sure

Has sustainability improved the company's competitiveness in the market?

- ☐ Yes
- ☐ No
- ☐ Not sure

Section 5: Challenges and Improvements

What are the biggest obstacles to sustainability in your company? (Select all that apply)

- ☐ Lack of awareness among employees
- ☐ Limited financial resources
- ☐ Weak regulatory enforcement
- ☐ Resistance from leadership
- ☐ Other (please specify): _____

How committed is your company to long-term sustainability goals?

- ☐ Not committed at all
- ☐ Somewhat committed
- ☐ Moderately committed
- ☐ Strongly committed

Do you believe that stronger government regulations would improve sustainability efforts in your company?

- ☐ Yes
- ☐ No
- ☐ Not sure

How would you rate the company's overall sustainability efforts?

- ☐ Very poor

- ☐ Poor
- ☐ Average
- ☐ Good
- ☐ Excellent

Section 7: Business Performance

How would you rate your company's overall financial performance in the past 5 years?

- ☐ Very poor
- ☐ Poor
- ☐ Average
- ☐ Good
- ☐ Excellent

Has the implementation of sustainable management practices led to an increase in profitability?

- ☐ Yes, significantly
- ☐ Yes, to some extent
- ☐ No noticeable impact
- ☐ No, profitability has declined

Which of the following performance indicators have improved due to sustainability efforts?

(Select all that apply)

- ☐ Cost savings from energy efficiency
- ☐ Increased customer satisfaction
- ☐ Improved brand reputation
- ☐ Higher employee productivity
- ☐ Growth in market share
- ☐ No noticeable improvement

How has sustainability influenced your company's competitive position in the market?

- ☐ Strongly improved competitive position
- ☐ Somewhat improved competitive position
- ☐ No significant impact
- ☐ Made the company less competitive

Section 7: Final Thoughts

Would you be interested in further training on sustainability management?

- ☐ Yes
- ☐ No
- ☐ Maybe

Have you seen an improvement in sustainability efforts over the past 5 years?

- ☐ Yes, significant improvement
- ☐ Yes, some improvement
- ☐ No noticeable change
- ☐ Sustainability efforts have declined

Do you believe that sustainability will become a core priority for the company in the next 5-10 years?

- ☐ Yes
- ☐ No
- ☐ Not sure

Author's Statement:

I hereby expressly declare that, according to the article 8 of Law 1559/1986, this dissertation is solely the product of my personal work, does not infringe any intellectual property, personality and personal data rights of third parties, does not contain works/contributions from third parties for which the permission of the authors/beneficiaries is required, is not the product of partial or total plagiarism, and that the sources used are limited to the literature references alone and meet the rules of scientific citations.