



Lisbon School
of Economics
& Management
Universidade de Lisboa

MASTER
MANAGEMENT AND INDUSTRIAL STRATEGY

MASTER'S FINAL WORK
DISSERTATION

**SUSTAINABLE VALUE CHAINS IN THE STAINLESS-STEEL INDUSTRY:
CHALLENGES AND OPPORTUNITIES**

MAUDE MULLER-BERNHARDT

JUNE-2025



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*“Fais de ta vie un rêve, et
d’un rêve, une réalité”
Antoine de Saint-Exupéry*

GLOSSARY

CBAM – Carbon Border Adjustment Mechanism

CEO – Chief Executive Officer

CE – Circular Economy

CRM – Customer Relationship Management

CSRD – Corporate Sustainability Reporting Directive

EAF – Electric Arc Furnace

EHV – Edelstahlhandelsvereinigung

ESG – Environmental, Social and Governance

EU – European Union

GHG – Greenhouse Gas

GVC – Global Value Chain

HR – Human Resources

ICT – Information and Communication Technology

IoT – Internet of Things

ISO – International Organization for Standardization

KPI – Key Performance Indicator

LCA – Life Cycle Assessment

LCT – Life Cycle Thinking

MFW – Master's Final Work

OEM – Original Equipment Manufacturer

R&D – Research and Development

ROI – Return on Investment

SBT – Science-Based Target

SBTi – Science Based Targets initiative

SCM – Supply Chain Management

SME – Small and Medium-sized Enterprise

TBL – Triple Bottom Line

ABSTRACT

This dissertation presents how stainless-steel firms can implement sustainable value chains while balancing profitability. This research utilizes the Triple Bottom Line framework to explore the answers of increased conflict between economic competitiveness and sustainability goals.

Semi-structured interviews with key industry stakeholders along the stainless-steel value chain highlight the strategy orientation, engagement and action taken by firms concerning sustainability in the industry's value chain. Findings reveal that while companies are embracing sustainability in strategic decision-making, they are faced with challenges such as supply chain complexity, regulatory uncertainty and competing cost pressures.

Despite such challenges, some businesses demonstrate how sustainability can be a driver for innovation, manager of risks, and market discriminator. The research shows that optimizing value chains for sustainability requires a departure from traditional models of efficiency to embrace systems which hold on to resilience, transparency, and co-creation with stakeholders.

This research contributes to sustainable industrial strategy literature in terms of industry-specific data and conceptualizing a framework for measuring stainless-steel industry sustainable value chain maturity.

KEYWORDS: Sustainable Value Chains; Stainless-Steel Industry; Triple Bottom Line; Circular Economy; Industrial Strategy; Supply Chain Management.

RESUMO

Esta dissertação apresenta como as empresas do setor de aço inoxidável podem implementar cadeias de valor sustentáveis ao mesmo tempo em que equilibram a lucratividade. Esta pesquisa utiliza o framework do Triple Bottom Line para explorar as respostas ao crescente conflito entre competitividade econômica e objetivos de sustentabilidade.

Entrevistas semiestruturadas com principais stakeholders da indústria ao longo da cadeia de valor do aço inoxidável destacam a orientação estratégica, o engajamento e as ações tomadas pelas empresas em relação à sustentabilidade na cadeia de valor do setor. Os resultados revelam que, embora as empresas estejam incorporando a sustentabilidade na tomada de decisões estratégicas, enfrentam desafios como a complexidade da cadeia de suprimentos, a incerteza regulatória e as pressões concorrentes de custo.

Apesar desses desafios, algumas empresas demonstram como a sustentabilidade pode ser um motor para a inovação, gerenciadora de riscos e diferencial no mercado. A pesquisa mostra que otimizar cadeias de valor para a sustentabilidade requer uma ruptura com os modelos tradicionais de eficiência para abraçar sistemas que valorizem resiliência, transparência e co-criação com os stakeholders.

Esta pesquisa contribui para a literatura sobre estratégia industrial sustentável, oferecendo dados específicos do setor e conceptualizando um framework para medir a maturidade da cadeia de valor sustentável na indústria do aço inoxidável.

PALAVRAS-CHAVE: Cadeias de Valor Sustentáveis; Indústria do Aço Inoxidável; Triple Bottom Line; Economia Circular; Estratégia Industrial; Gestão da Cadeia de Suprimentos.

TABLE OF CONTENTS

Glossary	i
Abstract.....	iii
Resumo	iv
Table of Contents.....	v
Acknowledgments	vii
1. Introduction.....	1
1.1 Background on the stainless-steel industry.....	1
1.2 Significance of the dissertation.....	2
1.3 Scope of the dissertation	2
2. Literature Review	3
2.1. Theoretical and Conceptual Foundations	3
2.2 From Supply Chains to Value Chains	6
2.3 Limitations of “Optimization” in Sustainability.....	8
2.4 Application to the Stainless-Steel Industry.....	10
2.4.1) The Role of the Circular Economy in the Stainless-Steel Value Chain .	12
2.5 Critical Review and Research Gap	13
3. Methodology.....	15
3.1 Research Design	15
3.2 Participant Selection	15
3.3 Data Collection	16
3.4 Data Analysis.....	16
3.5 Reliability and Validity.....	17
4. Data analysis and discussion of results.....	17

4.1 Overview of the participants.....	17
4.2 Sustainability orientation	18
4.3 Value Chain structure and key challenges	19
4.4 Measuring Performance	21
4.5 Organizational Governance and internal alignment	23
4.6 External collaboration.....	24
4.7 Economic trade-offs and profitability tensions.....	26
4.8 Barriers and Enablers.....	28
4.9 Future outlook.....	30
4.10 Discussion.....	31
4.10.1) Sustainability orientation: from strategic compliance to commitment	32
4.10.2) Value chain structure and challenges	32
4.10.3) Governance and cooperation	33
4.10.4) Economic trade-offs and profitability	34
5. Conclusion	36
5.1 Summary of the findings	36
5.2 Theoretical and Practical Implications	37
5.3 Study Limitations.....	37
5.4 Future Research Directions.....	38
References.....	39
Appendices	48
Appendix 1: Semi structured interview questions	48

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1. INTRODUCTION

As environmental concerns intensify, industries across the globe are under greater pressure to reduce their environmental footprint without compromising profitability. This has significantly increased the focus on sustainability in industrial supply chains, especially in energy and resource intensive industries. Among these, the stainless-steel industry holds a particularly pivotal role due to its essential application across sectors.

1.1 Background on the stainless-steel industry

Invented in 1913 by an English metallurgist Harry Brearley of Sheffield, stainless-steel has since become a cornerstone material of modern industry, known for its strength, corrosion, resilience and recyclability. Over the past century, it has played a vital role in developing modern infrastructure, industrial manufacturing and consumer goods. Nowadays, stainless-steel is utilized in most industries ranging from construction, automotive, and energy to healthcare devices.

In 2024, the global production of stainless-steel totalled over 62.6 million tonnes, marking a 7% increase from the previous year. (World Steel Association, 2024). This growth was led by Asia, particularly China which accounted for nearly 39.4 million tonnes, while Europe and North America contributed for 4.7 and 1.5 million tonnes, respectively.

One of the most characteristic features of stainless-steel is that it has a high service life and high recyclability with approximately 90% of stainless-steel being recycled during its end-of-life phase and almost 60% of its input material provided through scrap sources, making stainless-steel one of the most circular metals to be utilized (ISSF,2023). This positions stainless-steel as a front-runner material in advancing circular economy models and minimizing raw material extraction. However, despite these preferred attributes, production of stainless-steel itself is sustainable-intensive.

Optimizing sustainable value chains in the stainless-steel industry becomes both a requirement and a strategic need at this juncture. While the content itself is inherently appropriate for reuse in the long-term, the optimum impacts can be obtained only when upstream, midstream and downstream activities themselves are aligned to sustainability objectives.

1.2 Significance of the dissertation

Stainless-steel industry is at the crossroads of industrial requirement and sustainable responsibility. Stainless-steel is known for being long-lived, highly recyclable, and supportive of sustainable applications, yet, its production remains resource-intensive, relying on energy-consuming manufacturing processes, complex global supply chains, and often undisclosed origins. As policy makers institution redesign sustainability expectations across the European union and Worldwide market, companies are not just being asked to report on environmental performance but to transform the way they manage value chains.

Meanwhile, market dynamics are transforming. Industrial buyers and end-consumers increasingly demand low-carbon, traceable, and responsible material inputs. Yet, most stainless-steel businesses still struggle to implement sustainability principles in everyday practice, particularly when confronted with thin margins, regulatory complexity and global competition. The profitability-sustainable interface is not often considered a design issue but a trade-off opportunity. In addition, industry sustainability efforts focus on specific activities, such as energy efficiency and recycling, without addressing systems-level thinking in value chain optimization.

This dissertation is significant in that it explores sustainability not as a state but as an internally driven strategy process, facilitated by cross-functional coordination and inter-organizational collaboration. It contributed to the knowledge base in sustainable industrial strategy by grounding theoretical models, such as the Triple Bottom Line and circular value chains on real world practices and decision making throughout the stainless-steel industry.

In this regard, this dissertation offers to explore in depth these problems by analysing how firms in the stainless-steel industry can implement sustainable value chains while balancing profitability.

1.3 Scope of the dissertation

This study addresses the experiences, strategic choices, and organizational realities of firms that fill different step within the stainless-steel value chain.

The research is framed around three dimensions that frame the study. First, strategic orientation, examines whether sustainability is either cast in firms as compliance requirement, a brand differentiation, or a transformation goal over the long term. Second, value chain integration explores the extent to which sustainability is, or is not, integrated into sourcing, production, logistics and stakeholder interaction. At last, governance and metrics considers how organizational structures, leadership, and performance metrics align with sustainability aspirations and influence operational practice.

The dissertation focuses on five companies operating in various parts of the stainless-steel industry, selected for their different roles along the value chain. Through semi-structured interviews, the study makes a cross-sectional view of the way firms operate through sustainability in real-world operational and strategic constraints.

The dissertation aims to answer the research question through an introduction presenting the background of the industry, and the scope and objectives of the dissertation, but also through a literature review aiming to explore existing research on sustainability, value chains, and industrial strategy. This will set the context for a finer analysis and discussion of the collected data, to examine how sustainability is implemented across the value chain. Finally, the conclusion will summarize insights, provide recommendations, and suggestions for future research directions.

2. LITERATURE REVIEW

Business sustainability evolves from being a niche concern to becoming a central part of corporate strategy. Several theoretical perspectives are commonly used to understand how companies integrate sustainability into their operations and supply chains. In this thesis, the Triple Bottom Line framework will serve as the key analytical tool used in examining business sustainability within the stainless-steel industry.

2.1. Theoretical and Conceptual Foundations

One of the most influential frameworks linking organizational performance and sustainability is the Triple Bottom Line (TBL) model introduced by Elkington (1994). The framework proposes that companies should gauge their success through financial

returns but also through their environmental and social impacts. Taticchi and Demartini (2020) affirm the relevance of the TBL, emphasizing that corporate sustainability can be achieved only if the three dimensions, economic, environmental and social, are addressed simultaneously. As Savitz and Weber (2014) suggests, failure to address any of the outcomes might cause an overlooking of the factors that can affect it, as businesses operations rely on more than just financial capital, but also on the other dimensions of the TBL. The emphasis placed on each pillar of sustainability may vary according to the specific regulatory context of the industry. For instance, firms operating in pollution-prone sectors face more legislative pressure compared to firms in service industries (Engert et al., 2015). These pressures have led organizations to embrace the growing importance of social and environmental concerns. As Taticchi and Demartini (2020) demonstrate, reducing emissions and pollution is not merely a moral or regulatory imperative but a strategic one as well, since failure can result in a loss of reputation and reduced competitiveness in the market. While all three pillars of sustainability are important, their ranking typically depends on the environment in which a company operates.

Since the TBL was introduced, businesses have adopted a broadened view on their decision-making processes by adding dimensions of sustainability (Steyn and Niemann, 2013). While environmental and economic dimensions are easily quantifiable, social dimensions can be relatively challenging in terms of defining key performance indexes (KPIs) to use for measuring development (Azapagic and Perdan, 2000). Therefore, there is a need to approach sustainable development throughout the entire supply chain and create a co creation of sustainable value (Xiong, 2024).

The environmental pillar of the TBL framework demonstrate how companies manage their consumption of resources and minimize their impact on the environment. Corporate environmental consciousness has grown immensely over the past decades, particularly following global efforts like the Paris Agreement of 2015 (Bjørn et al., 2021). One of the key advances in this respect is the proposal of science-based targets (SBTs) that provide companies with a clear guide to translate their climate agendas into environmental ones based on climate science (Bjørn et al., 2021).

Among the tools proposed to support environmental goals are certifications, a credential that demonstrates a company's adherence to specific quality management and other standards set by the International Organization for Standardization (ISO). One of the most common worldwide standards for environmental management at a company level is ISO 14001 (Phan and Baird, 2015). Standardization through ISO 14001 provides companies with standard guidelines that enable them to enhance their environmental behavior in the long-term (Salim et al., 2017). However, the applicability of environmental behaviors varies among business sectors. According to González-Benito et al. (2008), the environmental activities that suit low-emitting companies may not be sufficient for those with great environmental consequences, which identifies context-oriented sustainability practices.

The economic dimension remains at the heart of companies' business practice, as it reflects a company's capacity to remain profitable, competitive and efficient over time. Steur et al. (2005) explain that economic sustainability has three facets from a corporate perspective. The first one concerns a company's financial well-being since no businesses can survive in the long term without healthy finances. This includes traditional performance metrics like profitability, cash flow, shareholder value, earnings, and liquidity. The second concern refers to the need for long-term competitiveness. Only when a firm continuously seeks to maintain or enhance its competitive edge in the market can it be referred to as economically sustainable. The third concern is the prolonged economic impact a company has on its stakeholders. A business is economically sustainable when it fulfills its financial responsibilities: paying taxes, compensating workers with fair wages, paying fair prices to suppliers, servicing its creditors and yielding returns to stockholders. In addition, Engert et al. (2015) point out that economic sustainability is not merely an end in itself but also a precondition for investment in more general sustainability measures. In the absence of a solid economic base, firms might not have the means to fund environmental or social development initiatives. Thus, economic feasibility serves as both a prerequisite and facilitator for sustainable development strategies.

The social dimension is interested in the relationship of the company toward people and society. It often relates to equity between and within generations. It encompasses

improving working standards and giving back to local communities (Steurer et al., 2005) Social responsibility is said to be defined by values of transparency, inclusiveness, openness, tolerance, and empowerment, challenging companies to build ethical and social supportive workplaces (Pucheta-Martínez et al. 2020)

Although the Triple Bottom Line model is transparent in nature, its implementation in real life is a set of challenges. Most companies are struggling to implement the three pillars in an equilibrium and integrated fashion, particularly for industries that consume more resources and global supply chains. Moreover, sustainability efforts are typically operated in silos by different departments, resulting in disconnected strategies rather than integrated value chain thinking (Lozano, 2007).

2.2 From Supply Chains to Value Chains

Traditional supply chain includes all actors involved in fulfilling a customer order and have typically focused on cost minimization and operational efficiency (Chopra & Meindl, 2016). Other scholars like Seuring & Müller (2008, p. 1700) go beyond Supply Chain by incorporating sustainability into it, producing *“Sustainable supply chain management the management of material, information, and capital flows as well as cooperation among companies along the supply chain while integrating goals from all three dimensions of sustainable development: economic, environmental and social”*. Ahi and Searcy (2013) argue that sustainability needs to be strategically integrated into each activity of the supply chain as opposed to an add-on.

As the complexity of sustainability challenges has grown and stakeholder expectations have become more diverse, literature has shifted away from the concept of supply chains towards the concept of value chains. While Porter's (1998) original model focused primarily on maximizing economic value by maximizing internal activities and minimizing cost through a chain of business activities, current literature suggests that such a strategy is too narrow to take account of wider environmental and social concerns facing firms today (Freudenreich et al., 2019). Stead and Stead (2019) claim, conventional models like Porter's do not account for ecological and social interdependencies, thus limiting their relevance in the modern-day, globalized business environments

Belvedere and Grando (2016) suggest a rigorous and pragmatic framework to integrate sustainability into operations and supply chain management by aligning managerial decisions with product life cycle stages. They include important stages such as sustainable product design, ethical sourcing, environmentally conscious manufacturing, eco-efficient packaging and distribution, and reverse logistics, by integrating instruments of the Triple Bottom Line (TBL). TBL allows value chains to integrate environmental and social value in addition to economic performance. It also involves taking into consideration the positive and negative externalities of business operations. Energy savings or cutting greenhouse gas emissions is traditionally addressed from a cost-reduction or regulatory-arbitrage point of view. However, this approach tends to consider environmental and social factors as externalities, rather than as integral components of value creation. As such, it can fail to address long-term risks and opportunities associated with system change (Linton et al., 2007). Value is no longer created merely by internal operations or profitability, but also by relationships, trust and the co-creation of effects that benefit a significant number of stakeholders (Normann & Ramírez, 1993). Value Chain is also an area where companies are meant to walk not just as economic actors, but also as environmental leaders and social contributors.

Freudenreich et al (2019) suggest that rethinking value creation in terms of TBL necessitates companies to consider both the positive and negative externalities of their operations. That is, the full life cycle impact of their products and services, from the extraction of raw materials to post-consumer waste, as well as the social impacts of their work practice and relations with stakeholders. For sectors such as stainless steel, where use of resources and environmental impact are both high, it is not only necessary for risk management but increasingly important to long-term competitiveness to use a value chain framework that incorporates objectives of sustainability. As Taticchi and Demartini (2020) support, not only individual excellence is required to obtain sustainability but instead the installment of the sustainability principles into the general chain of activity and interaction. This translates to operating on processes capable of reducing their environmental impact while they enhance community connection and maximize financial performance. The shift from supply chains to value chains is therefore no longer an option, it's a fundamental corporate purpose and obligation redefinition.

This broader vision aligns with systemic approaches to sustainability, where sectoral transformation and institutional change are emphasized. Scholars such as Loorbach et al (2017) and Geels (2011) note that transitions to sustainability require simultaneous changes across the whole sectors and institutions, as opposed to incremental changes at the firm level. In this perspective, companies are part of a broad framework within which they are required to collaborate with stakeholders for the purpose of addressing strategic problems such as climate change, resource deficiencies and social inequality.

2.3 Limitations of “Optimization” in Sustainability

In many industries, sustainability is viewed as an optimization strategy. Optimization is a search process for a specific problem under certain conditions of the problem given. Chelly Dagdia, Z., & Mirchev, M. (2020) describe that *“the notation of an optimization problem also implies that there is some objective function or functions that can be improved either by performing a minimization or a maximization action”*. Most companies often aim to reduce their emissions, energy consumption or waste in the best possible way, using instruments such as life-cycle analyses (LCA), lean manufacturing or data-driven key performance indicators (KPI) (Linton, Klassen, & Jayaraman, 2007; Hahn et al., 2010). While these efforts can result in measurable performance improvements, many researchers identify the broad deficits of optimization as the leading strategy to sustainability. (Pagell & Shevchenko, 2013; Hahn et al., 2014).

Optimization often favors economic gains at the expense of social or environmental goals. It assumes a stable system within which all variables are quantifiable, controllable, and can be enhanced incrementally (Hahn et al., 2010). Sustainability issues are usually non-linear and complicated, meaning trade-offs, feedback loops and unforeseen effects. Linton et al (2007) write that sustainability can no longer be considered as a second-order goal to be maximized within already established systems but instead needs to be designed into the systems from the very beginning. For instance, streamlining production in one part of the supply chain to reduce emissions can result in greater resource extraction or social disruption elsewhere (Hahn et al., 2010). It is therefore difficult to pinpoint one “optimum” that is optimal for all dimensions of sustainability. It also leads to superficial

sustainability efforts that produce good figures but minimal real-world impact (Hahn et al., 2014).

Another issue is that optimization focuses on existing processes and systems, without challenging their sustainability. It values effectiveness over transformation. As Fath et al. (2019) observe, ecologically and socially resilient systems need long-term, regenerative, adaptive solutions, not just effective ones. As a result, companies can offer incremental improvements in their environmental performance without necessarily calling into question their fundamental business models or practices resulting in long-term risks (Bocken et al., 2013). Similarly, Capra and Jakobsen (2017) point to the fact that living systems operate on the principles of feedback loops, interdependence and resilience, principles typically overlooked in optimization-based management models. Such a limitation is highly relevant in sectors such as stainless-steel, where significant change will probably be required to meet climate and resource objectives.

In addition, optimization techniques are generally firm-centered, around what a firm can control internally or impact via direct suppliers. However, as indicated by scholars such as Hopkinson et al. (2019) challenges like biodiversity loss, social inequality or circularity, need system-wide collaboration among industries, governments and society overall. Optimization models do not easily support co-governance or the co-creation of value across various stakeholders (Markard et al., 2012). Additionally, optimization is prone to incremental, as opposed to transformational, change.

Bocken et al. (2013) argue that sustainability challenges, especially for high-resource sectors such as steel, demand business model innovation rather than operational improvements. Similarly, Geissdoerfer et al. (2016) state that circular economy models present alternatives to optimization through material cyclical thinking, regenerative systems and resilience over the long term. However, such changes tend to also require a complete rethinking of value definition and delivery along the supply chain.

Even in companies that succeed in maximizing sustainability across their operations, externalities remain unaddressed. Kirchherr et al (2017) demonstrate that a majority of European companies are struggling with extending their sustainability activities to areas beyond what they can directly control, due to issues of traceability, engagement of

suppliers and governance procedures. This highlights the contrast between intra-organization optimization and change company-wide, particularly if suppliers come from nations having loose environmental or labor laws (Nandi et al., 2021).

Lastly, holding sustainability as an optimization problem tends to result in instrumentalization of the TBL whereby environmental and societal factors only account for mention in the financial realm (Elkington, 1998; Dyllick & Muff, 2015). This goes against the initial aim of TBL, which is to attain balance, not subordination, between its three pillars. Scholars have warned that this trend has the potential to make sustainability a branding or compliance exercise rather than a real shift in corporate strategy and culture (Schöggl et al., 2020; Lozano, 2007).

2.4 Application to the Stainless-Steel Industry

Applying the triple bottom line framework to the stainless-steel industry shows the versatility and complexity of integrating sustainability into a resource consuming, globally interconnected business. Stainless-steel industry has specific difficulties in satisfying simultaneous environmental, social and economic sustainability (Sverdrup, Koca, & Schlyter, 2019; Kirchherr et al., 2017). And yet, it also has a strong potential to be involved in the delivery of advances in sustainable value creation, namely through circular economy practice and cleaner production technology innovations (Holappa et al. 2021; Geissdoerfer et al., 2016; Hopkinson et al., 2019)

One of the main environmental issues of stainless-steel production is that it has high energy consumption and is characterized by carbon emissions. From an environmental perspective, the stainless-steel sector contributes to a major share of industrial emissions, energy consumption and raw material extraction. The production of Stainless steel includes inputs such as nickel, chromium and molybdenum, which are usually extracted under detrimental environmental conditions (Sverdrup et al., 2019). The carbon footprint of primary production is also brought into focus by the intense heat used for refining and melting, especially where power is from fossil fuels. Stainless steel is usually produced from electric arc furnaces (EAF), which can offer lower carbon emissions than the blast

furnaces used for carbon steel, but the required electricity still entails significant indirect emissions depending on the energy source (Holappa et al. 2021; Geissdoerfer et al., 2016).

Stainless steel is also recyclable, and the use of scrap in production can significantly reduce energy consumption and emissions. According to Holappa (2020), the sector is recording significant progress towards increasing the proportion of recycled content in its product, with notable progress in increasing the recycled content in its products, with some manufacturers reporting over 80% recycled content as inputs (Outokumpu, 2023). This aligns with the environmental pillar of the TBL and supports the need to develop circular value chains to reduce the consumption of virgin materials and ease the pressure on the climate (Geissdoerfer et al., 2016).

The economic pillar of TBL is also struggling with its own set of challenges in the stainless-steel sector. Profitability remains essential, particularly in an economy driven by fixed commodity prices and high global competitiveness. The integration of environmental and social objectives into business strategy is viewed as a cost rather than an investment, particularly when sustainability does not provide direct returns. Engert et al (2015) argue by asserting that economic sustainability is frequently a prerequisite for embarking on environmental or social projects, particularly in capital-intensive industries. Even so, companies that are at the cutting edge of sustainability can benefit from reputational advantages, risk mitigation and improved access to green finance or sustainability-related contracts, all of which can support long-run economic resilience. De Angelis (2022) argue that this short-termism is a legacy of linear economic models, where sustainability is seen as peripheral rather than integral to business strategy.

Social sustainability is the most challenging and less measurable area of the industry. In the stainless-steel sector, social issues are most critical in upstream operations such as mining, where unsecured working conditions, lack of safety protocols and conflict can occur. Govindan et al. (2020) have defined social sustainability as requiring transparency, inclusion, and empowerment, though these concepts are never fully realized in global value chains. In addition, the industry is coming under increasing pressure for its role in the long-term impact of extraction operations. Establishing responsible sourcing practices, engaging in multi-stakeholder dialogue and performing supplier audits are

some of the steps that businesses take to address these concerns, though enforcement and coverage remain unbalanced (Kirchherr et al., 2017).

The triple challenge of the stainless-steel industry is its ability to balance the three dimensions of TBL rather than maximizing them separately. While there have been some leaders, especially in emissions reduction and recycling, other firms are still largely focused on profitability. Taticch and Demartini (2020) explain, true sustainability is not just compliance or optimization, it must be integrated into the company's overall activities, culture and alliances. Moreover, since the industry is highly interconnected, company level transformation will frequently depend on system transformation, e.g., regulatory incentives, consumer demand for low-carbon materials and material science and metallurgy technological innovation (Loorbach et al., 2017). There will likely need to be a shift towards more integrated and systematic consideration of suppliers, customers, regulators and communities (Burch & Di Bella, 2021).

2.4.1) The Role of the Circular Economy in the Stainless-Steel Value Chain

The circular economy (CE) has in recent years been more and more recognized as a required framework for optimizing resource efficiency, waste reduction, long-term sustainability, and improving long-term competitiveness, particularly in material-intensive industries. Scholars such as Ellen MacArthur Foundation and McKinsey, (2013); Geissdoerfer et al., (2016) contrast the traditional linear economic model based on a "take-make-dispose" approach, with the circular economy model that seeks to achieve the decoupling of economic growth from the use of limited resources through the design of systems where materials are reused, recovered and regenerated. (Luis & Celma, 2020); Hopkinson et al., 2018) outline how the environmental and economic logic behind CE is also directly linked with the triple bottom line strategy, offering a complementary set of criteria for evaluating sustainability of value chains for such resource-intensive industries as stainless steel.

The stainless-steel industry already has relatively high rates of utilization of scrap, with electric arc furnaces enabling a significantly second life-based production process (Holappa et al., 2021). According to Reuter et al. (2005), minimizing the recycling and

redefining of stainless-steel scrap can help achieve significant savings in energy use and emissions along the value chain. However, the full attainment of a stainless-steel circular system depends on collection efficiency, effectiveness of sorting technology, and having an infrastructure capable of maintaining the integrity of the alloy through multiple life cycles (Rovanto & Bask, 2020).

Like other industries, the steel industry too faces challenges when adopting a circular economy. The operations of closed-loop supply chains, where recycled materials are retrieved to be processed anew, is particularly complex in an industry as dispersed worldwide as that of steel. De Angelis et al. (2018) uncovered that problems were largely connected to a lack of one definition of circularity and one clear value chain for recycled steel.

These challenges highlight that circularity is a social-economic transformation as well as a technological progress, but one which also requires multiple stakeholder strategies and supportive policy framework (Stahel & MacArthur, 2019; Parida et al., 2019).

2.5 Critical Review and Research Gap

Recent literature on sustainability in value chains has changed significantly, to include a bigger framework in the form of triple bottom line (TBL) thinking, circular economy, and systems thinking (Geissdoerfer et al., 2016; Hopkinson et al., 2019). However, there still exist certain gaps and contradictions, especially among those sectors which consume more resources, like stainless steel.

There is a significant tension in the literature between systemic sustainability efforts and efficiency-oriented measures. As Linton et al. (2007) and Hahn et al. (2010) highlight, most companies remain operationally focused when they address sustainability, attempting to reduce their environmental impact without challenging their existing business models. However, as elaborated by Bocken et al. (2013) and Geissdoerfer et al. (2016), such incremental changes are unlikely to contribute to the revolution required for long-term sustainability goals. These scholars focus on innovation in business models, stakeholder interaction, and a life-cycle approach, but very few studies demonstrate how companies overcome these issues in practice.

One of the contradictions is the uneven embedding of TBL's pillars. While economic and environmental considerations are strong because they are easily measurable, social sustainability remains poorly defined and operationalized (Azapagic & Perdan, 2000; Lozano, 2013). It is especially problematic in global value chains, where labor conditions, relations with the community, and human rights issues might be difficult to monitor or improve beyond first-tier suppliers (Kirchherr et al., 2017; Govindan et al., 2020).

Theorists have also explained conceptual ambiguity regarding the production of value in the quest for sustainable development. While Porter's original model of value chains (1985) continues to have influence, the model has increasingly been criticized as an excessively narrow economics logic. More recent approaches propose a shift towards circular, regenerative, and stakeholder-oriented value chains (Freudenreich et al., 2019; Stahel, 2019), yet empirical research into the manner in which companies are implementing these models, especially within heavy industry, is limited. Studies of these issues focus on individual companies or unique case studies without comparative analysis across environments or along the value chain.

In research on the circular economy, several authors write, even if the technical feasibility of closed-loop systems improves, their implementation is typically hindered by infrastructural, cultural and regulative constraints (De Angelis, 2018; Kirchherr et al., 2017; (Luis & Celma, 2020). This is particularly self-explanatory in sectors such as stainless steel, in which waste collection and alloy integrity depend on sophisticated coordination among numerous actors (Reuter et al., 2006; Holappa et al. 2021). In addition, circular strategies are also typically explored from an engineering or materials science perspective, rather than being theorized in broader discussions on sustainability governance, business strategy, and stakeholder involvement (Hopkinson, De Angelis, & Zils, 2019; Kirchherr et al., 2017).

According to those findings, this thesis aims to cover several important gaps. First, it aims to contribute to the literature by conducting an in-depth analysis of the TBL framework by the stainless-steel industry in its value chain strategies. The second aim is to investigate the ways in which circular economy principles are implemented beyond the technical aspects through investigating the interaction with profitability objectives,

stakeholder management and issues at a systemic level. Finally, it seeks to provide suggestions on how sustainability trade-offs are addressed in practice, drafting recommendations for more balanced and integrated value chain incorporation in high-impact sectors.

3.METHODOLOGY

This chapter introduces the methodological choices made to study how firms in the stainless-steel industry apply sustainability strategies to their value chains, based on the Triple Bottom Line (TBL) framework. The research design, data collection, sampling strategy and analysis procedures employed to establish validity and reliability are described in this chapter.

3.1 Research Design

A qualitative exploratory research design was used to gain in-depth understanding of industry experts of adopting strategy. As stated by Bryman (2016), qualitative methods are most appropriate for recording organizational processes and attitudes of stakeholders. Given the contextual and evolving nature of sustainability initiatives, interviews offered a flexible, yet structured means of data collection.

The study employed semi-structured interviews of various stainless-steel industry stakeholders, to allow the researcher to provide consistency between core themes and leave room for development and exploration of new topics (Kvale & Brinkmann, 2015). Multi-interview designs assure their relevance and validity of findings through cross-case comparison.

3.2 Participant Selection

The participants were sampled using purposive sampling, a method that seeks individuals with experience and expertise regarding the research topic (Palinkas et al., 2013). The selection criteria for the participants were those working in stainless-steel production, environmental management, value chain strategy, or sustainability roles. The objective was to get ideas from participants who hold decision-making, or

implementation roles related to environmental, economic, and social dimensions of sustainability.

They were approached via email or LinkedIn and provided with an information sheet explaining the research purpose, confidentiality procedures, and ethical aspects. The participants provided voluntary informed consent and signed a consent form prior to being interviewed. The final sample consisted of five participants from various companies in the stainless-steel sector, with diverse functions that ranged Managing Directors and CEOs to Purchasing Director and Plant Director.

3.3 Data Collection

Data were collected using semi-structured interviews, conducted during video conferencing software (e.g., Zoom, Teams). Interviews were guided by an open-ended structure derived from key themes formulated through the literature review, e.g., integration of sustainability, triple bottom line approach, circular economy practice, stakeholder engagement, and performance measurement. The interview questions can be found in appendix 1.

All the interviews took between 45 to 65 minutes and were recorded with the agreement of the participants. They were transcribed word for word and anonymized to maintain participant confidentiality. Field notes were also gathered during interviews for noting contextual observations and initial analytical impressions.

3.4 Data Analysis

Thematic analysis was used to analyze the transcribed data, adhering to Braun and Clarke's (2006) six-stage process. The process allowed the identification, organization, and interpretation of the patterns in the qualitative data. The analysis began by reading the transcripts repeatedly to familiarize with the study, followed by the generation of initial codes, which translates to highlighting, labeling, and sorting out key ideas from interviews. The codes were read, gathered, and built into larger themes that reflected the research objectives.

Themes were cross coded against the Triple Bottom Line (TBL) dimensions, economic, environmental, and social to facilitate systematic comparison across interviews and to connect the analysis to the conceptual framework of the study. Coding was noted manually and cross-checked to search for recurring patterns, contraction, and outliers that could sharpen the understanding of data. It was assumed that thematic saturation was reached when the final interviews did not generate much new information, and no additional major themes emerged within the date.

3.5 Reliability and Validity

Both reliability and validity were provided by employing a fixed interviewing protocol and clear documentation of data collection and processing. The latter was increased by methodological triangulation-verification of evidence drawn from the interview with other evidence such as industry reports and firms' sustainability reports (Yin, 2018).

4. DATA ANALYSIS AND DISCUSSION OF RESULTS

This chapter consist of the analysis and interpretation of findings retrieved from the semi-structure interviews conducted with five decision makers out of the stainless-steel industry. The collected data is assembled to provide a descriptive overview of the participants' responses under the key themes derived from the literature review and research objectives. According to the Triple bottom line framework, this analysis explains how sustainability is managed across various level of economic, environmental and social aspects in this industry's value chain.

4.1 Overview of the participants

The study sample include five participants occupying key strategic positions in their respective companies. The interviewees are referred to by their titles in the report to ensure consistency in reference and add credibility to their claims. Below, a short job description of each of the interviewees and an explanation of why they are considered pertinent in the gathering of empirical data:

Interviewee 1 was working as a company director for more than ten years and since January 2024 is a managing director of a European manufacturer. Referred to as “*Managing director*”.

Interviewee 2 is the owner and managing director of a stainless-steel company in Germany founded in 1996, that specialize in the production and distribution of stainless-steel pipe fittings. Referred to as “*CEO*”.

Interviewee 3 is a Purchasing Director for coils and plates in Germany. The business activity focuses on the processing of stainless steels, particularly special steels and clad materials, to create “*tailor-made product solutions*”. Referred to as “*Purchasing director*”.

Interviewee 4 is the CEO of a family-owned company for 7 years and is responsible for Brand Strategy and Digitization in a German company. Referred to as “*Family-owned CEO*”.

Interviewee 5 is the Director of a Steel plant in India, overseeing the entire transformation of raw steel bars into finished goods. Referred to as “*Plant director*”.

Collectively they represent a cross-section of the stainless-steel industry, ranging from Small and Medium Enterprises (SMEs) to large industrial company in Europe and India. Their activities are spread across the stainless-steel value chain, from hot rolling and welding to high-end machining and distribution of the end product. Their history and mindsets provide a useful background to the study of sustainability in an energy-intensive and large environmental-footprint industry.

4.2 Sustainability orientation

The various interviews provided two dominant mindsets towards sustainability in the participants: a compliance-driven orientation and a strategic orientation.

Three interviewees, the CEO, Purchasing Director and Family-owned CEO, indicated that organizational strategies for their company’s sustainability are mainly driven by regulatory compliance and supra-organizational certification requirement that is ISO 14001, or European policy and directive such as Carbon Board Adjustment Mechanism

(CBAM) or Corporate Sustainability Reporting Directive (CSRD). The companies view sustainability as a duty to meet pre-established legal and industrial standards, typically triggered by regulations or customer audits.

In contrast, two respondents, the Managing Director and Plant Director elaborated on a more future-oriented, proactive and strategy driven vision, viewing sustainability as a competitive success factor based on branding, digitalization and long-term company transformation. They view sustainability as part of their culture, and not just a checklist.

“These efforts reflect our ongoing commitment to reducing our environmental footprint across all areas of the company” Managing director (retrieved from interview, 2025).

“As a European managing a plant in India, I was worried about their sustainable impact and needed to make a change” Plant Director (retrieved from interview, 2025).

The scope of sustainability approach reflects general industry patterns noted in Lozano (2007), where integration is partial or problem-focused, especially in high-resource sectors.

The orientation difference has an impact not only on processes within but also on positioning in the outside world. Strategically oriented firms are likely to report sustainability activities openly, engage in innovations such as energy from renewable sources or process efficiency, and be open to stakeholder communication. Compliance-following firms, while still interested in meeting minimum standards, struggle to justify additional investment in sustainability unless it has some tangible financial payback.

4.3 Value Chain structure and key challenges

Analysis of the interview data suggest that even though stainless-steel value chain can vary in technical configuration between firms, the key sustainable challenges at each stage of operations are common. The evidence supports the discord that sustainability in industries like stainless-steel must be tackled on a macro level to cover the whole chain.

The value chain of stainless-steel typically includes steps such as raw material sourcing, production and transformation, finishing processes, and logistics and delivery.

The first step of the value chain is raw material sourcing which refers to the process of acquiring the base materials used in manufacturing. Many interviewees mentioned sourcing the materials from *trusted suppliers*, a status not solely based on ISO certifications, which are sometimes insufficient. In such cases, particularly with non-European suppliers, companies rely on additional controls such as audits conducted by the company itself. These audits include visit to check that everything is in order and to ensure that the supplier meets internal criteria and is not engaging in below-standards activities. This multi-stage checking allows companies to ensure that their raw material sourcing aligns with both quality and sustainability expectations. The Purchasing Director and Family-Owned CEO raised concerns regarding traceability of origin, environmental damage through extraction and limited availability of reclaimed materials. The Plant director mentioned selecting suppliers based on use of renewable energy. The main concern at this first stage of the value chain is upstream transparency, where interviewees mostly rely on certifications and standards of their suppliers to ensure the ability to track and verify the origin, processing history and sustainability practices of the materials to ensure an ethical supply chains and “*act according to our principles which are public available, laws and regulations*”, Purchasing Director (retrieved from interview, 2025)

The raw materials are then processed in the second stage of the value chain which is the production and transformation of the materials. It translates to cutting, rolling and heat treatment of the materials. Energy and emissions use were among the most significant challenges noted by the Managing Director, the Family-Owned CEO and the Plant Director. The interviewees recognize their awareness to the energy consumptions, carbon emissions and scrap generation produced during this stage. While the CEO and Plant Director indicated efforts to optimize their production processes to minimize waste, such initiatives are often not standardized across departments or facilities.

The finishing stage in the stainless-steel value chain included a range of critical steps such as cutting to length, machining, chemical treatments, surface finishing and quality checking. Water use, the use of chemicals and occupational health risks are involved. The Family-Owned CEO used waste management and chemical use explicitly in reference to sustainability issues. Other find challenges in the quality check since “*product are also tested, to either certain standards or individual customer requirements*”, Managing

Director (retrieved from the interview, 2025), The Plant director explains that *“internal transformation steps are always according to the most efficient and green production structure using green energy”* (retrieved from the interview, 2025).

The final stage of the stainless-steel value chain, logistics and delivery, presents unique environmental and operational sustainability issues. While often under-emphasize in industry reports, this process contributes considerably to a company’s Scope 3 Carbon Emissions, with ongoing transport emissions and packaging waste. While the CEO’s recycling of packaging by *“reusing packaging materials from incoming shipments for our own deliveries”* and *“reduced paper consumption in our administrative processes by implementing modern software solutions, allowing us to operate with virtually no paper-based documentation”* is a testament to sustainability, other interviewees identified logistics as a “blind spot”, having to few data to monitor transport-linked emissions.

“Each steps carries its own issues, ethical concerns while sourcing, energy consumptions during manufacturing, chemicals during finishing, or carbon emissions during transportation. The challenge is to be able to track and react to all of them.” Family-Owned CEO (retrieved from interview, 2025).

The value chain structure is a critical factor in achieving sustainability results. Each phase from upstream sourcing to downstream delivery carries distinctive environmental and social impact which are usually aggravated by supply chain transparency gaps, technological limitations or developing metrics.

4.4 Measuring Performance

Collection and analyses of data to measure performance is a critical but complex element of value chain optimization in the stainless-steel industry. Interview data suggest that while the majority of companies use a mix of quantitative key performance indicators (KPIs), the strategic integration and consistency of these measurements varies notably and their connection to long-term value creation is often underdeveloped.

All five interview participants reported tracking at least some sustainability-related metrics, with energy efficiency, carbon emissions with Scope 1,2,3, waste reduction and

water consumption being the most frequent ones. Four of them reported having incorporated in their KPIs the tracking of carbon emissions, recycling and waste reduction. However, social and economic dimensions were less recurrently analyzed, though, the CEO communicated on measuring return on sustainability investment (ROI) explicitly by *“looking at ROI on solar panels and reuse of packaging. It has to make economic sense”*.

A few companies are also taking initial steps on digital performance tracking and Environment Social and Governance (ESG) reporting. The Purchasing Director highlighted the use of external evaluation platforms like Ecovadis, while the Family-Owned CEO described the assignation of an ESG Development Manager with cross-departmental oversight for tracking and progress.

Despite such practices, the data propose strategic and operational deficiencies. For instance, none of the respondents measured social metrics, such as employee wellness, supply chain labor conditions, or stakeholder engagement on a regular basis, which are principal components of the Triple Bottom Line Framework. Moreover, the data standardization and interdepartmental alignment were not highly developed in most companies. The Plant Director reported that while monthly briefings were conducted, the lack of shared reporting systems makes benchmarking difficult.

This disconnection is also evident in the literature. Measures of sustainability, for instance, have a strong focus on environmental outputs, with little consideration for the organizational systems required to incorporate those measures into decision-making (Lozano, 2007). In high-impact industries like stainless-steel, this gap can limit the translation of data into action.

Another repeated theme was the lack of Scope 3 visibility, especially in logistics and procurement. Only one company described concerted efforts to accounts for indirect emissions and supplier performance. Two interviewees acknowledged these areas were underdeveloped but difficult to prioritize due to cost and resource constraints.

“Our Scope 1 and 2 emissions are well-monitored, but when it comes to Scope 3 especially transport and supplier emissions, we are mostly in the dark. It’s just extremely

complex and expensive to track with the resources we currently have” Family-Owned CEO (retrieved from interview, 2025).

Jointly, these results indicate that while most companies engage in performance measurement, there is a maturity gap between operational KPI tracking and strategic sustainability management. Lastly, accounting for what matters is not a question of metrics alone, it is a question of aligning performance with purpose. Without this alignment, sustainability can be compartmentalized rather than institutionalized in the stainless-steel value chain.

4.5 Organizational Governance and internal alignment

Organizational governance and internal alignment are key drivers of sustainability in the stainless-steel industry. Interview evidence suggests that the extent to which sustainability is embedded in internal organization, leadership roles, and inter-departmental coordination as a direct correlation with the success and consistency of sustainability activities.

Several interviewees underlined that sustainability cannot be entrusted to one team or department. The Family-Owned CEO attributed sustainability as a mission to be shared where *“every department has its own role to play”* and stressed the recruitment of an ESG Development Manager for embedding sustainability goals across functions. Cross functional integration is optimal practices in governance for sustainability where integration between procurement, operations, R&D and finance are considered to be the magic key to successful implementation.

“Someone needs to lead, but everyone needs to put their input in”, Plant Director (retrieved from interview, 2025)

The Plant Director also described frequent meetings between departments to allow for collective sustainability development, but admitting a lack of standardized reporting. Again, this finds a common thread, although commitment at the highest level exists, many companies do not yet have systemic processes and tools in place to ensure regular practice by every team. The Managing Director corroborated this by saying that sustainability

goals were referred to on a strategic level but, as an opposing force, operational departments were not necessarily adequately informed or incentivized to report.

The Purchasing Director accentuated compliance as one major internal driver for alignment towards sustainability, inclined to associate procurement decisions with external principles and standards. However, these risks limiting broader organizational responsiveness and learning, as it is more rule-following than building internal stake and innovation.

Although the participants revealed differentiated levels of governance maturity, the most innovative firms are beginning to implement sustainability responsibilities, obligations and performance measures in the organizational fabric. The alignment between organizational governance and environmental goals will be the prime factor that decides the degree of integration achievable in practice. Without properly established frameworks and accountability, even highly ambitious sustainability strategies can be plagued by fragmentation and inconsistency throughout the value chain.

4.6 External collaboration

External cooperation with external stakeholders such as customers, suppliers, regulators and industry associations play an important part in stainless-steel's value chain. The degree of implication of external collaboration varies significantly between companies.

Interview findings reveal levels of maturity and inclination for outside collaboration. The Managing director described the interaction with external stakeholders as minimal, primarily limited to feedback and insights gained through customer audits, with no structured process of interaction. Thus, this strategy is mostly triggered from the outside when interaction occurs.

The CEO described a more proactive, yet pragmatic approach. The company listens to customers inputs and adjust where it is compatible with their business operations, while maintaining good relationship with regulators. These actions are still, however, driven mainly by internal feasibility and compliance, not by proactive co-development.

The Family-Owned CEO presented the most formalized view of cooperation outside the company. The company is building sustainability partnerships across the supply chain by engaging in responsible sourcing, collaborative product development with consumers and staying attuned to evolving ESG norms through conversation with regulators and industry associations.

The Plant Director is the only interviewee to be deeply involved in any industry-wide association or regional networks, which reveals the company's involvement in wanting to make a change in the industry. The Plant Director reported participating in national and regional associations such as the India Tube Association and *Edelstahlhandelsvereinigung* (EHV) in Germany.

India Tube Association, a professional trade organization representing manufacturers, producers and negotiators of tubes and pipes in India, serves as a platform for networking and collaboration, technical exchange and standard-setting and as a policy advocacy with government bodies. *EHV* is a similar networking, policy advocacy and service provider for German stainless-steel distribution.

These affiliations are seen as strategic leverage points rather than merely formal memberships. The interviewee accentuated that being part of such collectives amplifies their voice when engaging with regulatory institutions, particularly at the European or national level. Membership comes with conditions, including financial contributions and adherence to governance principles, but it enables shared knowledge and influence over economic and sustainability-related policy developments.

"It gives us more influence than standing alone in front of the institutions", Plant Director (retrieved from interview, 2025)

This form of indirect collaboration through industry associations serves not only to gather insights but also to move the regulatory environment, highlighting the interdependency between firms and institutional frameworks in shaping sustainability governance.

4.7 Economic trade-offs and profitability tensions

Balancing profitability and sustainability have turned into one of the longest-running concerns for stainless-steel companies, particularly in a cost-competition-driven market, with a historical infrastructure and a globalized supply chain. The data collected during the interviews shows a dual story, while some have started to marry environmental action with profitability, others remain hesitant, perceiving sustainability as a cost center rather than a strategic asset.

Two participants asserted categorically that sustainability can be a force for competitiveness. They provided examples such as product innovation based on customer requirements for sustainability, participation in trade exhibitions for the purpose of establishing brand value, and gradual implementation of measures for environmental sustainability that add to marketability. These firms view sustainability as a force for differentiation and long-term brand value.

“We promote sustainability to earn more profits, step by steps. Fairs, communication and cooperation with challenging customers create a reputation for sustainable product”, Plant Director (retrieved from interview, 2025).

“We propel sustainability initiatives that also bring economic return, such as boosting energy efficiency and aligning product development with customer requirements”, Family-Owned CEO (retrieved from interview, 2025).

On the other hand, three of the interviewees expressed doubt about the current feasibility of balancing sustainability and profitability simultaneously. One of the participants openly acknowledge the absence of a defined strategy to address this trade-off. Another described a pragmatic approach, where sustainability measures, such as reusing materials, or the implementation of green energy such as solar panels investments, were adopted only when they offered a clear financial benefit. These efforts were not framed as long-term transformation goals but rather as cost-saving opportunities.

“Sustainability is important, but without customer willingness to pay more or concrete incentives, it’s simply not viable for us to prioritize it over core operational costs”, Managing Director (retrieved from interview, 2025).

This reflects a more widespread fear in the industry that customers and market forces are not yet fully aligned with the cost of sustainable change, particularly price sensitive markets. The Purchasing Director mentioned the firm's ESG reporting and preparedness for CSRD and ESRS compliance, did not show evidence of economic return from such efforts but did mention transparency and future expectations of compliance.

Sustainability is filled with inherent trade-offs and tensions, rather than neat win-win scenarios. Particularly in industries that are resource intensive like stainless-steel, the upfront investment to modify facilities, systems and supply chain can be significant. The tension is then aggravated by the low willingness of customers to pay a premium price for sustainable products and services creating a disconnection between strategic aim and operational viability.

“Sustainability brings value in branding and export markets, but customers rarely pay more”, Plant Director (retrieved from interview, 2025).

When asked if sustainability and competitiveness can now coexist together in the industry, the interviewees were divided between the answers *“not currently”* and *“I strongly believe so”*. Three of them indicated that economic pressures, uncertainty, the absence of transparent demand, along with structural constraints, continue to limit the business case for sustainability.

However, two of them strongly believed that competition and sustainability synergy was achievable, and that perception and management of trade-offs were significantly determined by mindset, strategy and positioning.

In general, the evidence suggests that while islands of success exist, sustainability would be pursued where it can be economically justified on the short-to-medium time horizon. Systemic change in the longer term must be driven by greater integration between customer demands, regulatory regimes, and internal cost bases. Without integration, sustainability is a marginal activity rather than a central driver for long-term stainless-steel companies.

4.8 Barriers and Enablers

The data retrieved from the interviews demonstrate that there are significant barriers to the transition to sustainable value chains for the stainless-steel industry, but there are also various enabling factors.

One of the most common complaints raised by the interviewees is the cost of new technology and infrastructure upgrades. Investments in sustainability such as solar panels, chemicals waste treatment installations, or high technology monitoring equipment are viewed as too expensive without immediate tangible returns.

Internal knowledge deficiency was identified as a limitation as well in several interviews. Although companies may have strategic ambitions, their implementation of environmentally friendly practices is lacking due to shortage in departments' knowledge. One of the participants emphasized that departmental meetings are held monthly for checking on sustainability, but without shared systems or standardized knowledge among teams, there cannot be profound action.

“We are still learning how to take strategy and put it into practice. It’s not just about targets, it’s about knowing what to do in every job”, Family-Owned CEO (retrieved from interview, 2025).

A related obstacle is operational-level resistance to change. Despite leadership declaring goals and targets, departmental inertia will often find expression in gradual implementation. The Managing Director admitted that although sustainability is used strategically, operational staff may not have adequate information or incentives to react accordingly.

“We have overall objectives, but they are not always integrated into what departments do on a daily basis”, Managing Director (retrieved from interview, 2025).

The complexity surrounding supply chain was also cited as a structural constraint. Most of the interviewees rumbled about upstream obscurity, low visibility into the operations of suppliers and scattered standards across countries and markets. One interviewee pointed out the environmental and ethical risks of raw material sourcing,

another said that small suppliers shun the spotlight because they have little direct leverage, but together they might be big sustainability risks.

“It’s hard to follow what happens upstream. We have supplier certifications, but we can’t always guarantee how well they can be trusted”, Family-Owned CEO (retrieved from interview, 2025).

“Extremely small suppliers are not audited by us for sustainability because they contribute little to our Scope 1,2 and 3”, Purchasing Director (retrieved from interview, 2025).

These challenges were also accompanied by some enablers that allowed companies to transition towards sustainability objectives, as revealed through the interviews.

A key enabler is strong leadership commitment. Most interviewees have appointed a role for monitoring sustainability or have defined responsibilities to make sure that their strategies could be implemented. The Plant Director also underscored leadership’s role in guiding sustainability not just for compliance purposes but as a strategic market driver.

Innovative technology also proved to be an excellent trigger. Investments are made in various stage of the value chain, such as renewable energy or waste recycling systems.

Another enabler recognized is outside pressure, namely from customers and regulators. Regulatory guidance such as the Corporate Sustainability Reporting Directive (CSRD) and the Carbon Border Adjustment Mechanism (CBAM) are not only encouraging companies to shift but also providing a clear direction and incentive for change in the long term.

Lastly, industry discussion and peer collaboration, both in their growing phases, were seen as early supports. The Plant Director noted that since becoming a member of national and European steel associations, the company’s agenda and aims were more defined and influenced into the direction of sustainability.

Stainless-steel industry appears to be in a transitional phase where enablers are starting to take advantage on the barriers, at least in leading companies. The challenge will be scaling these practices throughout the value chain and reinforcing that sustainability within strategic and operational levels.

4.9 Future outlook

As the stainless-steel industry maps its path to sustainable value chains, the need for digitalization and circularity cast a large shadow as the drivers of future transformation. Data retrieved from the interviews indicate that while there is universal conceptual support for these strategies, their operational implementation is uneven and often plagued by technical, economic or cultural constraints.

Digitalization particularly by means of technologies such as blockchain, Internet of Things (IoT) and advanced monitoring systems is watched with cautious interest. Interviewees recognized the potential of digital technology to enhance sustainability, specifically traceability, databased decision making and transparency of performance. One of the interviewees noted that the company's effort to digitalize administrative and procurement processes was a step toward digitalization. Another one uses external measuring platforms such as Ecovadis, although it is not yet fully integrated into operational software.

Despite the positive trends, there remains scepticism. Some interviewees voiced being concerned over implementation complexity, the risk of unclear return on investment and technical unreadiness of their teams.

“We comprehend the advantages of digital tools in principle, but struggle to integrate them into our operations with clear payback”, Managing Director (retrieved from interview, 2025).

Although digital technologies can provide new capabilities for sustainability, they demand large investment upfront, cross-functional coordination, and effective governance to yield benefits.

On the other hand, circular economy (CE) concepts such as closed-loop systems, greater recycled content, and product lifecycle extension are better identified as necessary, but not quite operationalized yet. Every participant noted the significance of waste minimization and reusing material.

While stainless-steel is among the world's most recycled materials as 90% of stainless-steel is already made of scrap, the path of higher circularity remains challenging. Participants noted that recycling is already industry standard, but closed-loop systems at scale, for instance recycling material to the same use or facility, is not something feasible and economical. One of the main technical barriers is that the high corrosion resistance of stainless-steel, while best for longevity and long-term use, can complicate remelting, passivation and re-certification processes, especially where precise alloy contents must be produced for high-specification applications.

In addition, over 100 million tonnes of carbon steel (World Steel Association, 2024) are lost each year globally to corrosion, a huge point of leakage in the circular economy. This loss represents the durability versus circularity paradox: stainless-steel is durable and delivers good performance but, when corrosion takes hold, recovery is more difficult, particularly when parts are embedded in infrastructure or dispersed in low-turn applications.

Thus, while recycling levels are high, actual material circularity where materials are not only recycled, but recaptured and re-used in the same or greater value chains, continues to be inhibited by structural and technological limitations.

The implementation of circular economy is not a technical problem, but more of a system redesign issue requiring convergence of company culture, customer demand, finance, and engineering. The destiny of stainless-steel sustainable value chains will likely depend on the ability of firms to not just adopt but internalize these models into the very heart of their functions, decision-making, and stakeholder engagement.

4.10 Discussion

A discussion of the data presented follows. The purpose of this discussion is to interpret and describe the meaning of the data collected in the light of what was already known about the topic from the literature review or to propose a new understanding that emerges as a result of the study.

4.10.1) Sustainability orientation: from strategic compliance to commitment

There is a distinct contrast between companies that view sustainability as a compliance requirement and those that leverage it as a platform for creating value. This is reflective of the typologies of Lozano (2007), who differentiate between companies that include sustainability in culture, governance and decision-making and those that still focus on regulatory compliance.

In order to make the shift from compliance to commitment, companies must begin to view sustainability less as an off-the-main street endeavour and more as a fundamental to competitive strategy. One key insight from the literature is that sustainability is a source of sustained value when it is linked to innovation (Porter & Kramer, 2011). Stainless-steel firms can use sustainability as a tool for product differentiation (e.g., low-carbon alloys, circular products to order), as a brand building tool (e.g., green export market certifications), and as an efficiency tool (e.g., resource minimization, waste reduction).

Going further, companies can set incentive systems for mid-level and operational managers in line with sustainability KPIs, or embed ESG goals into executive compensation, a trend gaining hold among forward thinking business (Taticchi & Demartini, 2020). Internal transformation also encompasses building capacity: sustainability literacy cannot only be confined to leadership or ESG roles but cascaded through systematic employee training for procurement logistics, and production teams.

Outside the firm, connecting strategic sustainability to investor stakes may also release financial capital. Firms that surpass regulation are more appealing to sustainable finance platforms and ESG investors, who can provide new sources of funding for initiatives of modernization.

4.10.2) Value chain structure and challenges

One of the most heartfelt tensions revealed through the interviews is that value chain complexity, most commonly advanced as a barrier to sustainability, is likewise its greatest lever. Taticchi and Demartini (2020) argue that sustainability cannot be achieved through linear interventions but will need to pursue systemically across all stages of the value

chain. The evidence is that very few firms are currently engaged in this systems-level thinking.

To address this, stainless-steel businesses can benefit by conducting full life cycle assessments (LCA) to identify cradle-to-gate sustainability hotspots. Most initiatives today focus on production energy and emissions, with untransparent raw material sourcing and downstream delivery. A complete LCA would be in a position to enable action plan targeting, such as buying low-impact alloys, making contrasts with eco-certified carriers, or designing close-loop return systems for cut-off and scrap products.

In addition, traceability platforms of the supply chain and digital twin technologies can be used to model environmental and social impacts in real-time. These platforms allow companies to execute “what-if” scenarios (e.g., virgin content vs recycled content), which improve strategic decision-making.

At the industrial level, pooled investments in shared infrastructure, such as local recycling facilities, green energy clusters or pooled logistics to end delivery, may fall per unit cost burden while enhancing sector-wide impact. These are validated by theoretical literature regarding cooperative industrial ecosystems and circular supply chains (Geissdoerfer et al., 2016).

Finally, standards organizations and regulators can implement benchmarking and openness by requiring value chain reporting, especially in European framework like CSRD. The companies that set themselves up for readiness today will be well ahead of the market when these requirements expand in reach.

4.10.3) Governance and cooperation

The study finds that organizational designs within companies are drivers of how sustainability is imagined and achieved. Formal ESG roles, cross-functional integration, and top-down sponsorship have been found to realize more success in connecting sustainability with everyday decision-making. This aligns with Pagell and Wu (2009) in that they argue that translating sustainability into actions requires more than just intention, but also rigorous coordination, accountability and organizational memory.

However, interviews also revealed that company efforts lack integration with external ecosystems, joint work with supplier, authorities and consumers is primarily reactionary, occurring through audits or feedback systems. Still sustainable transformation requires multi-stakeholder innovation systems. To move forward, stainless-steel companies need to become more proactive in shaping their operating environment.

Internally, companies can establish cross-functional sustainability councils with procurement, finance, HR, and operations members, meeting regularly to plan together on progress, bottlenecks and innovation needs. These councils would be empowered to make budget and supplier decisions based on their footprint versus cost or Leadtime.

Externally, firms must go beyond bilateral relationships and participate in industry-wide efforts such as ResponsibleSteel or EUROFER's decarbonisation roadmap. These platforms offer not only best practice, but policy-shaping opportunities that can de-risk innovation.

Furthermore, agreeing on mutual sustainability goals with suppliers, such as shared GHG reduction targets or recycled content levels, can help to share ESG responsibilities across the chain. Businesses can also benefit by using supplier development programs to increase the level of sustainability performance of small, high-risk suppliers, particularly those beyond the EU.

Lastly, external legitimacy is conducted via transparency. Disclosures of sustainability objectives, audits reports, or supply chain impacts on platforms such as Ecovadis may enhance stakeholder trust as well as provide access to reputation and financial benefits.

4.10.4) Economic trade-offs and profitability

Although most of the sustainability literature is focused on optimizing efficiency, the findings through this research suggest that optimization alone may be insufficient in addressing the root systemic issues of stainless-steel companies. This is reflective of Hahn et al. (2014) call to move beyond "business-case sustainability" and the inherent paradoxes of sustainability transitions.

Interviewees consistently indicated a desire to reduce emissions, improve traceability, and manage waste, but in nearly all instances, this extends only so far as incremental adjustment within existing business paradigms. For example, replacing virgin inputs with recycled stainless-steel is circumscribed by governments and quality constraints, as well as technical possibility, and the utilization of green energy plants is often dependent on external subsidy or client leverage. These examples serve to illustrate that optimization is conducted under constraints which are both internal (budgetary and knowledge-based) and external (regulatory and market-based).

Therefore, among the most consequential strategic challenges is the balance between the short-term cost justification of manufacturing operations and longer-term systems redesigning that sustainability naturally requires. Corporations remain hesitant to take on radical redesigning, whether shifting business models to leasing, R&D investment in collaborative closed-loop metallurgy, or transforming product lifecycles to prioritize reuse over throughput. These paradigms, cited within circular economy and post-growth business theory (Bocken et al., 2013) offer routes to sustainability but challenge conventional measures of success.

Furthermore, the fragmented extent of responsibility along the value chain makes this issue more problematic. Large Original Equipment Manufacturers (OEM) and big buyers can potentially have leverage to compel sustainability, but smaller converters and producers, like some that were interviewed, can hardly juggle such demands with their location in global spread web of supply. Power imbalances suppress innovation here.

Therefore, to transform towards transformative sustainability, stainless-steel companies must shift from a paradigm of optimization with constraints to one of strategic experimentation and collaborative redesign. This could be developing shared infrastructure for recycling recovery perhaps through public-private partnership; Exploring new business models on durability, service contracts or modularity; Cooperating pre-competitively on greener alloys or traceability platforms; Re-focusing on value creation that encompasses resilience, equity and regeneration over profitability.

In this view, industry association, public bodies, and cross-sectoral partnerships are most important. Firms cannot mount the type of experimentation necessary by

themselves, an innovation coalition strategy is required. This fits with transition management theories (Loorbach et al., 2017), which highlight experimentation, niche incubation, and policy support in socio-technical transitions.

Overall, optimizing current systems can delay emissions, save money, and get more competitive, but without a more radical interrogation of what the system optimizes for, these efforts risk remaining superficial. Strategic change within the stainless-steel industry will depend on embracing complexity, leveraging partnerships and boldly questioning the assumptions of industrial value creation.

5. CONCLUSION

Based on the Triple Bottom Line (TBL) theory and empirically informed through semi-structured interviews with five industry stakeholders along the stainless-steel value chain, the study laid bare the ways in which businesses are responding to increased sustainability pressures while operating within operational, economic, and institutional constraints.

5.1 Summary of the findings

The research found that although sustainability is gaining traction in the agendas of businesses, its integration onto the three pillars of the TBL of economic, environment, and social is not even. The environmental and economic pillars are integrated primarily by way of energy efficiency, compliance certification, and strategic innovation, while the social pillar is underdeveloped and rarely tracked beyond tier-one suppliers.

Participants demonstrated two contrasting orientations: compliance-oriented, where sustainability is essentially a response to regulations, and strategic, where firms treat sustainability as an engine of innovation, brand strength, and risk mitigation. Across the value chain, from raw material sourcing to production, finishing, and logistics, serious challenges include traceability, energy use, waste, and Scope 3 emissions. Even as certain firms track sustainability performance through KPIs and ESG ratings, gaps in available data on social impact and procurement upstream continue to hinder full integration.

Interview respondents also revealed tensions between profitability and sustainability in the short term versus the long term. Some organizations had adopted sustainability as

a source of competitive advantage based on grounds of innovation and stakeholder trust. Other organizations viewed it as an economic burden where there was no willingness to pay by customers or clear regulatory incentives. Despite these tensions, several enablers existed like leadership, stakeholder engagement, and industry association membership.

Digitalization and circular economy strategies were identified as promising trends, yet their application remains patchy. While stainless-steel is theoretically recyclable, closed-loop cycles and complete traceability of materials remain impossible on a large scale owing to technical and infrastructural limitations.

5.2 Theoretical and Practical Implications

The findings support a groundbreaking critique within sustainability literature: conventional optimization-based models underutilize the dynamics of sustainable change, particularly in high-impact sectors. The study supports the theoretical pendulum shift from linear supply chains to systemic value chain thinking, which aligns stakeholder co-creation, feedback loops, and long-term value creation. The findings call for stainless-steel firms to: integrate sustainability goals beyond ESG disclosure, engaging with procurement, operations, and strategic planning; Enhance governance structures through cross-functional sustainability teams, holding mechanisms, and in-house training; Increase stakeholder alignment with suppliers, regulators, and industry bodies to drive collective transformation; Leverage life-cycle analysis and digital technology to improve traceability and assess sustainability trade-offs systematically.

5.3 Study Limitations

This study is not free from limitations. Firstly, empirical information came from a small group of five industry stakeholders, who were all Europe-based, so the potential for generalizing the results is undermined. The sample cannot reasonably represent opinions from emerging economies or other regions of the stainless-steel value chain.

Secondly, the research was conducted using qualitative data, which, while rich in understanding, is based on subjective experience and perception rather than quantitative performance measures. This precludes statistical confirmation of trends or outcomes.

Lastly, focus on the stainless-steel industry, while appropriate in view of its environmental footprint and circular value, may not directly generalize to other, less resource-intensive industries.

5.4 Future Research Directions

The subsequent research steps can be pursued in the following ways:

- Quantitative performance analysis: Investigate how sustainability indicators are implemented and whether they lead to measurable environmental, social, or economic benefits in the long run.
- Comparative studies: Compare across regions (e.g., EU vs. Asia) or between sub-sectors (e.g., stainless-steel vs. carbon steel) to study how different contexts influence implementation.
- Longitudinal studies: Track companies over time to observe how promises of sustainability evolve and what habits stick around.
- Digital and circular innovation: Research how emerging technologies such as blockchain, AI, and IoT can increase value chain transparency, stakeholder engagement, and material recirculation.

As the stainless-steel industry continues to struggle with the twinned mandate of competitiveness and sustainability, this dissertation offers a rooted but prophetic input to both manager and scholar alike. The path to sustainable value chains might be more complex, but it is clearer than ever that cooperation, innovation, and strategic reappraisal are prerequisites for developing a stronger and more just industrial future.

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APPENDICES

Appendix I: Semi structured interview questions

Introduction

Hello and thank you for agreeing to participate in this interview. I am Maude Muller-Bernhardt, and I am currently in the process of preparing my thesis for my master's in management and industrial strategy at ISEG-Lisbon School of Economics & Management.

My thesis focuses on the way stainless-steel companies can achieve optimal sustainable value chains, while maintaining profitability and environmental responsibility.

This is a semi-structured interview, so I prepared some guiding questions, but we can also explore themes based on your insights. There are no right or wrong answers. I am simply interested in your perspective and experience. This interview will be around 45 to 60 minutes long and, with your permission, will be recorded to ensure accuracy. All your responses will be anonymized and kept confidential in the final report, unless otherwise requested.

Before we begin, do you have any questions?

Part 1: Role and company's background

- Could you briefly describe your current role and responsibilities and how long you have held this position?
- How would you characterize your company's overall approach to sustainability?

Part 2: Understanding the value chain in the stainless-steel industry

- Could you describe the main stages of your company's value chain, from raw materials to customer delivery?
- What are the major sustainability issues at each stage?

- How are decisions made when it comes to selecting suppliers or partners in terms of sustainability?

Part 3: Sustainability strategy and integration

- What were the main motivations for implementing sustainable practices in the company?
- Which standards or framework (ISO 14001, GRI, SDGs, CSRD...) guide your sustainability efforts?

Part 4: Monitoring and Measuring sustainability

- What are the KPIs that you track to monitor sustainability across your value chain? (e.g., efficiency, ROI, brand value,...)
- How do you measure your performance across environmental, social and economic dimensions?
- Other ways?

Part 5: Collaboration, Governance, and Stakeholders

- How do you collaborate with suppliers, customers or regulators to improve sustainability across the value chain? (e.g, joint sustainability projects, shared emissions data, regulatory collaboration)
- How are internal department (e.g., procurement, operations, finance) involved in sustainability goals?
- Are you involved in any industry-wide associations or multi-stakeholder initiatives (e.g, ResponsibleSteel, ICM, EHV)?

Part 6: Trade-offs, Profitability and Competitiveness

- What strategies does your organization use to balance sustainability and profitability?

- Do customers or investors demand more sustainable practices or products, and how do you respond?

Part 7: Enablers and Barriers

- What have been the main barriers to implementing sustainability initiatives?
- What has enabled progress (e.g, leadership commitment, technology, stakeholder pressure)?
- Have regulatory changes (e.g, EU Green Deal, CBAM) created constraints or opportunities for your sustainability aspirations?

Part 8: Future Outlook

- Where are you seeing the most opportunities for promoting sustainable value chain in your industry?
- Are there any new trends or innovations (e.g, digital traceability, green steel, circular economy) which you are exploring?
- Will digitalization (Blockchain, IoT) play a significant role in making supply chains more sustainable?

Part 9: Sustainability and Competitiveness

- Do you believe that a firm can be competitive and sustainable simultaneously in the current stainless-steel industry?
- To your knowledge, has sustainability assisted your organization in terms of innovating or enhancing efficiency, or has it mostly brought additional costs or complexity?
- Did you observe an attitude shift in the industry? From seeing sustainability as a constraint to seeing it as an opportunity?
- Would your customers pay more for sustainable products or processes?