Transforming the European Fashion Industry: Strategies and Practices towards Environmentally Sustainable Production – A Systematic Literature Review

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Abstract

Title: Transforming the European Fashion Industry: Strategies and Practices towards Environmentally Sustainable Production – A Systematic Literature Review
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This thesis examines how European fashion companies can transform towards environmentally sustainable production to reduce CO2 emissions and create value. A systematic literature review is conducted that covers literature between 2012 and 2022. The research identifies key drivers, potential benefits and challenges of sustainable production, and strategies and practices for implementation. The findings highlight internal and external factors driving the shift towards sustainable practices, including government regulations, market forces, and organizational values. This paper emphasizes operational and organizational practices that can help introduce sustainable production. The Enterprise Transformation Cycle is applied to analyze the aspects of change that are necessary for the transformation of sustainable production. The findings provide actionable insights for adopting a holistic approach encompassing strategic management, process innovation, organizational restructuring, and cultural change to ensure the structure is aligned with the new business approach. Many references prove that introducing sustainable production positively affects the environment through lower CO2 emissions and on the business by achieving competitive advantages. However, challenges such as scalability, investment requirements, and resistance to change within companies still exist. The analyzed changes underline the need for a fundamental transformation of the fashion industry towards a sustainable business model. This work is a reference for academics and practitioners on implementing and developing sustainability practices in the fashion industry's production. This applies not only to European fashion companies but may also be relevant to other markets where sustainability matters.

Keywords: Environmental Sustainability, Corporate Social Responsibility, Production, Fashion Industry, Sustainability Transformation

Sumário

Título: Transformar a Indústria da Moda Europeia: Estratégias e Práticas para uma Produção Ambientalmente Sustentável - Uma Revisão Sistemática da Literatura
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Esta tese analisa a forma como as empresas de moda europeias podem transformar-se numa produção ambientalmente mais sustentável para reduzir as emissões de CO2 e criar valor. É efetuada uma revisão sistemática da literatura que abrange a literatura entre 2012 e 2022. A investigação identifica os principais fatores, os potenciais benefícios e desafios da produção sustentável, bem como estratégias e práticas eficazes para a sua implementação. Os resultados destacam fatores internos e externos que impulsionam a mudança para práticas sustentáveis, incluindo regulamentos governamentais, forças de mercado e valores organizacionais. Este documento destaca não só as práticas operacionais, mas também as práticas organizacionais que podem ajudar a introduzir a produção sustentável. O Enterprise Transformation Cycle é aplicado para analisar os aspetos da mudança que são necessários para a transformação e prol de uma produção mais sustentável. As conclusões fornecem informações úteis para a adoção de uma abordagem holística que engloba a gestão estratégica, a inovação de processos, a reestruturação organizacional e a mudança cultural, a fim de garantir que a estrutura está alinhada com a nova abordagem empresarial. Muitas referências provam que a introdução da produção sustentável tem efeitos positivos para o ambiente, através da redução das emissões de CO2, e para a empresa, através da obtenção de vantagens competitivas. No entanto, ainda existem desafios como a escalabilidade, os requisitos de investimento e a resistência à mudança nas empresas. As mudanças analisadas sublinham a necessidade de uma transformação fundamental para um modelo de negócio sustentável.

Palavras-chave: Sustentabilidade Ambiental, Responsabilidade Social das Empresas, Produção, Indústria da Moda, Transformação da Sustentabilidade

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List of Abbreviations

CO2	Carbon Dioxide (CO2 instead of CO_2 for reasons of better readability)
SDGs	Sustainable Development Goals
CSR	Corporate Social Responsibility
kg	Kilogram
Gt	Gigatons
°C	Grad Celsius
GHG	Greenhouse Gas
GHGE	Greenhouse Gas Emissions
rPTE	Recycled Polyester
EU	European Union
n.D.	No Date
SBTi	Science Based Targets Initiative
ETC	Enterprise Transformation Cycle
SLR	Systematic Literature Review
PPA	Power Purchase Agreement
LCA	Life Cycle Assessment
RFID	Radio-Frequency Identification
KPIs	Key Performance Indicators

1. Introduction

"The IPCC essentially confirmed what we already knew: The window of opportunity to secure a liveable and sustainable future for all is rapidly closing. But it did offer a glimmer of hope. If we act fast, act together and sustain that momentum, we can turn things around."
(European Institute of Innovation and Technology Climate-Knowledge and Innovation Community, 2023).

Science has done its job by showing the intensifying climate crisis (IPCC, 2021) and growing stakeholder expectations (Diabat, Kannan, & Mathiyazhagan, 2014; Tapaninaho & Kujala, 2019). Policymakers are critical on the road to a sustainable future. However, businesses can be an even greater transformative force for sustainable development and need to contribute to this development. Now, it is up to companies to take ownership and execute. Therefore, we need to shift the focus from commitment to action.

The progress of the fashion industry does not keep up with this urgency. It is one of the slowest developing industries in the direction of sustainability and, therefore, "[…] remains far from sustainable" (BCG & GFA, 2019). Companies in the fashion industry are under enormous pressure to manage this complex shift to becoming sustainable, as four to ten percent of yearly worldwide carbon dioxide (CO2) emissions are caused by the industry. This is more than all international flights and maritime transport (Niinimäki et al., 2020; Roland Berger, 2022; The World Bank, 2019). Unless there is an anticipated turnaround, the 2030 emissions reduction targets will be missed by 50%, leading to accelerated global warming (McKinsey & GFA, 2019).

European fashion companies are global players that can exploit loopholes in markets with lower environmental standards (Thorisdottir & Johannsdottir, 2020). Increased consumer awareness of these issues means less room for dual standards. Customers expect global companies to take responsibility at the local level. In today's business landscape, the fashion industry in Europe is facing a crucial shift, underlined by the increasing need for sustainable practices. It requires a paradigm shift that reflects regulatory compliance and is deeply rooted in a conscientious consumer trend that demands transparency, ethical practices, and environmental responsibility (Pui-Yan Ho & Choi, 2012). Therefore, sustainability must become a guiding principle in the fashion industry (The World Bank, 2019). In practice, however, this also means doing everything differently. Thus, production adaptation and innovation are essential in improving environmental performance and creating value for the company (Pal & Gander, 2018; Wong & Ngai, 2021). Sustainable production practices not only reduce the carbon footprint but also align with the United Nations 2030 Agenda

on Sustainable Development Goals (SDGs) – Goal 12, responsible consumption and production (United Nations, 2015).

Sustainability in the fashion industry has been discussed in the literature for several years. Existing research already focuses a lot on sustainability in the supply chain of the fashion industry (Kazancoglu, Kazancoglu, Kahraman, Yarimoglu, & Soni, 2022; Turker & Altuntas, 2014; Wren, 2022). A vital contribution to sustainable supply chains has been made by Seuring and Müller (2008), who designed a framework for sustainable supply chain management but not specific to the fashion industry. The study by Moretto et al. (2018) outlines a 5-step roadmap for implementing sustainability practices in the fashion supply chain. Other studies look at sustainability initiatives, such as the targeted use of materials (Costa & Broega, 2023). Although the existing literature addresses the question of what activities are available to improve environmental performance, it lacks an overarching framework that shows how to successfully adopt the activities in production from a practical and organizational point of view. Studies like Bocken et al. (2014), which demonstrate how business model innovation and sustainability work together, already take a similar position but use a different model and method of analysis. They mainly focus on the business model rather than how it has changed or what steps have led to it.

For this reason, the model of the Enterprise Transformation Cycle (Pfannstiel & Steinhoff, 2018) will be used to illustrate this process. It shows which additional elements are needed to carry out transformations in companies. It is well known for the organization of digital transformation, but it can be transferred well, as sustainability is also about a fundamental change in how enterprises create value. To complete the existing research area, this thesis aims to answer the following research questions:

How can European fashion companies transform towards environmentally sustainable production to reduce CO2 emissions and create value?

This research question can be divided into three sub-questions:

- *What are the key drivers for the transformation towards sustainable production?*
- *What are the potential benefits and challenges of sustainable production?*
- *What are the strategies and practices to transform towards sustainable production?*

While the concept of sustainable production is not new, its application and implementation in the European fashion industry are subject to a variety of challenges. This involves the balance between improving environmental performance and increasing value creation at the same time.

The objective is to identify the key drivers for sustainable production transformation, including internal and external factors. Further, potential benefits and challenges associated with the transformation, including environmental and economic aspects, are evaluated. Moreover, practices and strategies for sustainable production are analyzed. Finally, the findings are synthesized into actionable insights and recommendations that provide a roadmap for companies aiming to transform toward sustainable production.

To obtain these objectives, the work is structured as follows. The relevant theoretical foundations for answering the questions are discussed in Chapter 2. In this context, terms such as sustainability, fashion industry, and transformation are defined with the help of relevant literature. In addition, the significance of sustainability as a strategic business task is examined in more detail through the literature. Moreover, the current state of fashion production, the associated process stages, and their impacts will be described. The Enterprise Transformation Cycle relevant to the discussion is introduced as well. The methodology underlying this thesis is explained in more detail in the third chapter. The general procedure of the literature search is presented, and search terms and inclusion and exclusion criteria are determined. Chapter four presents the findings of the analysis used to answer the research questions. A discussion and critical examination of the findings follow in chapter five. Theoretical and practical implications are derived, and the limitations of the work and the need for further research are discussed.

2. Theoretical Foundations

2.1 Sustainability

2.1.1 Definition and Delimitation of the Term

The business literature in the field of sustainability is a growing area of research. The topic has been on the agenda of business studies since the 1970s (Friedman, 1970). Due to changing definitions and interpretations over time, there are several concepts of sustainability in the business context in the literature. Corporate Social Responsibility (CSR) is a key term when it comes to implementing sustainability in a company. The term refers to the concept of sustainability, representing the core concept. The United Nations Brundtland Commission defined sustainability in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1988). The definition underlines the inherent tradeoff of any action between the generation's needs of today and tomorrow. Current business literature defines the term as the simultaneous consideration of environmental, social, and economic dimensions as a criterion for corporate action (Purvis, Mao, & Robinson, 2018). These three dimensions are directly related and should be understood as equally important to enable sustainable development (Bansal, 2005). The three pillars of sustainability are also known as the triple bottom line (Elkington, 1999). Anglo-American definitions, such as Porter and Kramer (2002), in which CSR is understood as public involvement, only represent a small section of the previous definition. In this case, the focus is solely on the use of profits, not on the generation of profits. This is also known as corporate citizenship or corporate philanthropy. The four-stage pyramid, according to Carroll (1979), which shows the economic, legal, ethical, and philanthropic responsibility of companies, also deviates from the current, holistic definition of sustainability. It becomes clear that CSR has evolved from a philanthropic and defensive character to a strategic corporate charter (Werther & Chandler, 2005) and can be considered synonymous with sustainability in the corporate context (Commission of the European Communities, 2001).

The definition of Responsible Business builds on the definition of CSR but goes further. A Responsible Business is a company that has sustainability at the core of its strategy, in a holistic sense (environmental, economic, social dimension) as a source of competitive advantage, with an integrated view of the relevant stakeholder's interests that advance the society's well-being and sharing the same broader purpose (Moreira da Cruz & Pires de Almeida, 2020).

The stakeholders mentioned in the definition of Responsible Business are an essential addition when defining sustainability in the business context. Freeman's stakeholder theory goes back to 1984 and is a crucial basis for understanding economic and social relationships. It looks at the connections between business and society (Wong & Ngai, 2021). Following the stakeholder theory, companies interact with various interest groups and therefore have a responsibility towards them. Stakeholders include all parties that have a relationship with a company, including employees, investors, suppliers, customers, communities, and other interest groups of the organization. These groups pursue conflicting goals, which result in demands for different corporate efforts (Freeman, 2010). In the literature, this theory is used to present different viewpoints on CSR. It also offers an approach for evaluating CSR implementation at the company level (Mcwilliams & Siegel, 2001). The theory can be used to examine how companies adjust their sustainability targets by showing the extent to which the target depends on the degree of stakeholder involvement and external expectations (Loew, Ankele, Braun, & Clausen, 2004).

2.1.2 Sustainability and Value Creation – The Business Case

A major focus of the existing research is to determine whether sustainability has a positive impact on the company's bottom line. Whereas in 2007 it was still said that there was no significant evidence of a positive impact on a company's financial performance of CSR (Barnett, 2007), a positive trend was already apparent in 2009 in the study by Perrini, Russo, Tencati und Vurro (2009) and 2010 in the meta-study by Loew and Clausen (2010). Later studies on the subject become even clearer. Several authors concluded that there is a clear positive correlation between sustainability and the performance of a company (Gupta & Gupta, 2020; Hult, Mena, Gonzalez-Perez, Lagerström, & Hult, 2018; Jung, Nam, Yang, & Kim, 2018; Magon, Thomé, Ferrer, & Scavarda, 2018; Wong & Ngai, 2021). Porter and Kramer (2011) argued that creating shared value for the company and society can strengthen competitiveness if it is strategically anchored in the company. The study of McWilliams and Siegel (2011) as well as Wong and Ngai (2021) also found that sustainability can help companies maintain a competitive advantage in the market. CSR can serve as a strategic tool for positioning in the market and increasing the company's value (Stierl & Lüth, 2015). Positive economic development includes making profits, attracting customers, selling products, reducing costs, managing long-term risks, and creating jobs. These factors contribute to the promotion of long-term competitiveness (Mahler, 2007). In addition, CSR becomes the benchmark for corporate decision-making, management, and control as well as the further

development of the business model. This results in sustainable risk management that takes opportunities and risks into account. Conversely, companies may face increased risk if they do not apply CSR holistically or do not see it as a strategic task (Mayer, 2017). There are hardly any studies in the literature that prove the opposite, in which sustainability harms the company's performance. One study by Naranjo-Gil (2016) concluded that the implementation of environmental measures can have a negative effect on the company's performance in the short term but a positive effect in the long term.

The sustainability of value creation can be analyzed using the three dimensions of the triple bottom line, namely economic, environmental, and social performance (Elkington, 1999). However, due to the scope of the work, only the ecological and economic dimensions will be highlighted to ensure an in-depth analysis and meaningful results.

2.2 European Fashion Industry

2.2.1 Fashion Value Chain

The word fashion is a collective term for clothing, apparel, footwear, garment, or textile (Hines & Bruce, 2007). The fashion industry was one of the first to move across national borders and is today most characterized by international division of labor (Schneider, 2003). In contrast to the European comparison, Eastern countries have lower environmental regulations and lower labor costs (Martinuzzi, 2011). Since the end of the 20th century, the relocation of production from industrialized to emerging markets has been taking place, leading to the emergence of new growth opportunities (Nguyen, Le, Ho, & Nguyen, 2020). The resulting ability to produce fashion faster and in shorter cycles has fundamentally changed both production and distribution and the entire value chain (Haddick, 2018). Fast fashion comes with a phenomenon of its own. The lead time for fast fashion production is two weeks for Zara and eight weeks for H&M (Rashmila, 2023). The resulting challenges along this value chain are the enormous demand for resources and labor issues in the production process (Nguyen et al., 2020).

Today, European fashion companies organize a complex value chain that consists of several interconnected steps that contribute to the production and distribution of fashion products. It extends from design through the sourcing of materials and production to distribution and retail (Niinimäki et al., 2020). Production can take place both in the fashion companies' production facilities and in external suppliers' factories (Neugebauer & Schewe, 2015). A closer look at the design, production, sales, and headquarters of the brands reveals a dichotomy. It divides the global

north from the global south (Niinimäki et al., 2020). While production often takes place in countries like China, Bangladesh, India, Vietnam, Pakistan, or Indonesia (Textile Exchange, 2018), design and sales take place in the global north, including Europe. The headquarters of the fashion brands are also located here (Niinimäki et al., 2020). In this context, an efficient supply chain is of fundamental importance (Neugebauer & Schewe, 2015). From an economic point of view, such as cost and time efficiency, the throughput of the supply chain means that social and ecological concerns are often pushed into the background (Eggert, 2015).

This work focuses on the production of fashion items because these processes have the highest emissions (*Figure 1*). In this context, we are speaking about the four tiers of the fashion value chain, which represent over 80% of the emissions in the fashion industry. Office buildings, retail, and distribution (Tier 0), as well as consumer use, end-of-life, and transportation are not considered as they represent a significantly smaller share of the emitted emissions. The four steps of production include raw material extraction (Tier 4), raw material processing (Tier 3), material production (Tier 2), and finished goods manufacturing (Tier 1). The raw material extraction stage begins with sourcing raw materials such as cotton or synthetic fibers. Afterward, they undergo raw material processing, where they convert into usable forms, such as spinning fibers into yarn. The subsequent material production stage includes textile formation like knitting and dyeing. Finally, the manufacturing of finished goods involves cutting and sewing fabrics into garments (Sadowski, Perkins, & McGarvey, 2021). Overall, the production is marked by dependence on fossil resources as a material and energy source and the use of hazardous chemicals and dyes, many also based on petroleum (Palacios-Mateo, Van Der Meer, & Seide, 2021).

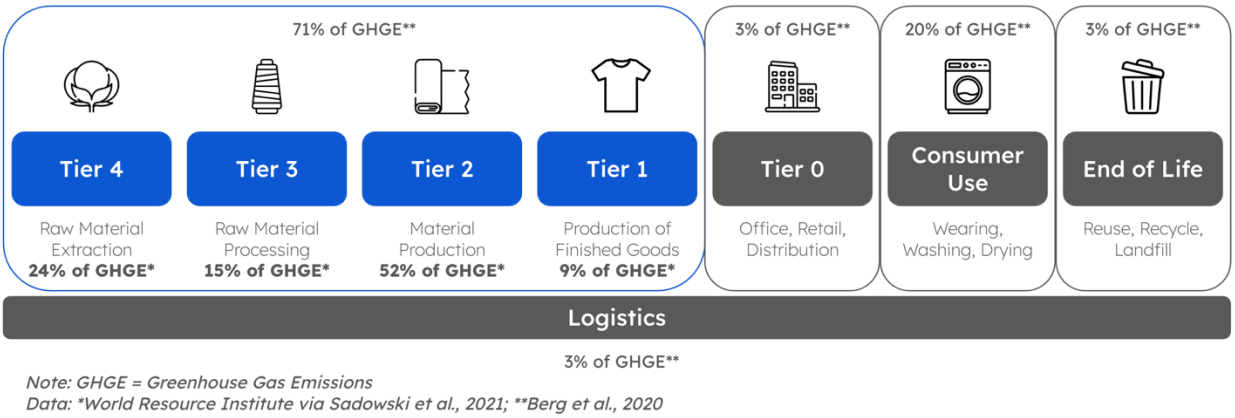

Figure 1: GHG Emissions of Fashion Value Chain based on Sadowski et al. (2021)

2.2.1 Emissions

Numerous gases, known as greenhouse gases (GHG), have different magnitudes of impact on global warming. CO2 is one GHG and the most emitted in the fashion industry (Eryuruk, 2012). "The fashion industry's high carbon footprint comes from high energy use and is influenced by the source of the energy used" (Niinimäki et al., 2020). CO2 is produced by the combustion of fuels and the generation of electricity from fossil sources. Coal is one of the most used fuels in fashion production facilities. It is used for heating water, dyeing fabrics, and generating steam (Sadowski et al., 2021). The per capita consumption of textiles in the EU caused carbon emissions of 270 kilograms (kg) in 2020 (European Environment Agency, 2022; European Parliament, 2020).

If the sector is going to increase at a normal rate, emissions in 2030 are predicted to reach 1.588 gigatons (Gt). The sector needs to cut emissions from 1.025 Gt in 2019 to 0.564 Gt by 2030 to achieve a 45% reduction and stay within a 1.5°C trajectory. Assuming the prediction of 1.588 Gt under business as usual, the industry must lower emissions by more than one Gt by 2030, along with more by 2050 (Sadowski et al., 2021). In the upstream activities, emission savings of around 60% are achievable. A reduction of 20% can be achieved through measures relating to the brands' activities. The remaining 20% remains with a change in consumer behavior (Berg et al., 2020). GHG-related pollution is often unaddressed because of a lack of understanding and control across various action areas (Saha, Dey, & Papagiannaki, 2021). This work aims to contribute to that effort.

2.2.3 Materials

Most materials in the fashion industry are associated with agriculture and mineral oil, and therefore, "climate action starts at the source of the materials […]" (Textile Exchange, 2023a). Cultivation and extraction of raw materials account for around 24% of total emissions of the value chain. Emissions from the production of polyester rank first and cotton second. Thereby, the use of polyester is increasing and was around 52% of all fabrics in 2019. Cotton is in second place with 23%, followed by 6.4% man-made cellulosic fiber, and finally, nylon with 5% (Sadowski et al., 2021).

Preferred fiber or material is defined by Textile Exchange as "a fiber or raw material that delivers consistently reduced impacts and increased benefits for climate, nature, and people against the conventional equivalent, through a holistic approach to transforming production systems." (Textile Exchange, 2023b). This definition covers the ecological and social dimensions of sustainability and additionally aims at the transformation of production systems. For simplification

and the limited scope of this work, sustainable materials are defined as those with lower greenhouse gas emissions per unit compared to conventional alternatives, such as organic cotton to conventional cotton or recycled compared to virgin polyester. For example, organic cotton produces around 50% less emissions compared to conventional cotton due to the reduced use of fertilizers and pesticides as well as better agricultural techniques (Berg et al., 2020; Davila, Herrera, Hunter, Martin, & Winkler, 2019). Recycled polyester (rPET) also has about 40% fewer emissions than conventional polyester due to closed-loop production processes and material recycling (Berg et al., 2020).

2.2.3 Relevance of Sustainability in the Fashion Industry

Today's fashion industry is pushing the use of natural resources to its limits through mass production and a low-cost structure that encourages general consumerism (Thorisdottir & Johannsdottir, 2020). At the same time, there is a growing awareness of the environmentally harmful consequences of the fashion industry, which is helping to promote "[…] the emergence of new, more sustainable models of organizing production and consumption" (Pal & Gander, 2018). Effective use of internal and natural resources in an industry characterized by short life cycles and strong competition (Wong & Ngai, 2021) is therefore essential to achieve environmental performance and value creation.

Moore and Ausley (2004) found that implementing environmentally conscious production practices in the textile industry can lead to an increase in productivity, a reduction in costs, and better environmental and human health outcomes. In addition, the paper deals with the importance of systems thinking and stakeholder engagement when adopting greener production principles. It also addresses legislative pressures that have led to the development of new approaches to environmental improvement.

The Green Deal of the European Union from 2019 is one example of a regulation that can have a big impact on the industry "to move to a clean, circular economy and stop climate change, revert biodiversity loss and cut pollution" (CBI, 2022; European Commission, 2019). The goal is to reach climate neutrality by 2050 for the entire continent. With the EU Strategy for Sustainable and Circular Textile*s*, the European Commission is going one step further and is specifically addressing the production and consumption of textiles, targeting the entire lifecycle of the products (European Commission, n.d.). A circular economy is a system in which materials are never wasted, and nature is regenerated. Therefore, products and materials are kept in a loop through operations

such as maintenance, reuse, refurbishment, remanufacture, recycling, and composting (Ellen MacArthur Foundation, n.d.). Some clothing brands are already investigating innovative, circular business strategies. Although these models currently account for a minor portion of revenue, those focused on reuse, rental, and repair exhibit the potential for lowering emissions (Sadowski et al., 2021). Since the circular economy represents a completely new approach to the creation of value and the production of goods, it considers the entire value chain and goes well beyond production. As it also includes production, it is listed here but not analyzed in its entirety.

There is an increasing number of companies joining the Science Based Targets initiative (SBTi). The SBTi shows companies how far and how fast they need to cut their GHG emissions to avoid the worst effects of climate change. In doing so, they define and promote best practices for emissions reduction and net-zero targets in line with climate science (SBTi, n.d.). As of 2022, "125 companies and 41 supporting organizations, including major global brands such as Inditex, H&M, and Nike, have signed up to the initiative" (Roland Berger, 2022). The goal is to reduce emissions by 45% by 2030 and to be net zero by 2050 (Sadowski et al., 2021). In addition, the United Nations Fashion Industry Charter for Climate Action has already been signed by 100 signatories from 23 countries. It pursues the goal of reducing GHG emissions by 30% by 2030 and the commitment to analyze and define a decarbonization pathway for the fashion industry based on the methods of the SBTi (UNFCCC, n.d.).

2.3 Transformation

2.3.1 Definition

Transformation means to reshape or redesign an object from a state A to a new state B. Unlike transition, which describes a change with the elimination of old structures and the creation of new structures, whereas transformation describes change with fluid reshaping (Czekala, 2018). In the business context, transition refers to a period of change from one state to another, while transformation refers to a fundamental change in how a company operates (Hölscher, Wittmayer, & Loorbach, 2018).

Companies are subject to constant change, both internally and externally. When change is to be anticipated, two change approaches are often used, namely organizational development and change management (Steinhoff, 2018). Organizational development focuses on enhancing employees' and the company's potential, driving change from within. In contrast, change management aims for radical, external renewal by creating new approaches and structures with

goals that go beyond the current system. Transformation management merges these methods, combining organizational development's internal logic with change management's external perspective. This promotes change from both inside and outside and can develop further through synergy effects (Prammer, 2009; Steinhoff, 2018).

2.3.2 The Enterprise Transformation Cycle

The Enterprise Transformation Cycle (ETC) can be used to understand transformation at the company level in theory and practice. The model was developed by the German consulting firm Transformation Consulting International (TCI, 2018) and was published by Pfannstiel and Steinhoff (2018) in the academic context. The ETC underlines the permanent process of change and considers dependencies that arise during the transformation process. Seven dimensions of the ETC encompass each changing area within the organization, thus providing a holistic view.

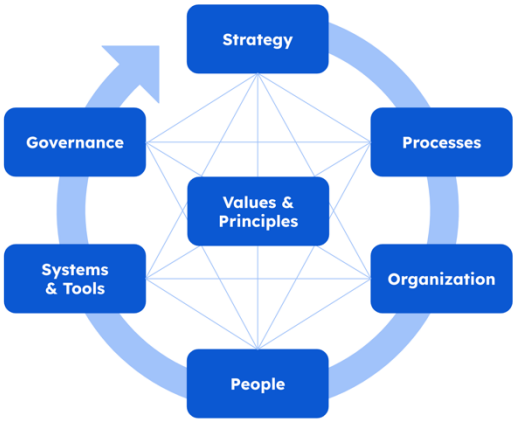

Figure 2: The Enterprise Transformation Cycle based on TCI (2018) and Steinhoff (2018)

Values and principles are at the center of the model and are interconnected to each dimension. Together, they form the corporate culture (Steinhoff, 2018). Corporate culture can be defined as a shared set of values, beliefs, assumptions, and principles of members from the same organization (Ravasi & Schultz, 2006; Schein, 1990). According to Steinhoff (2018), corporate cultures differ depending on the region and organization and can even vary within companies. During a transformation, companies must be able to deal with different cultures. The company culture can therefore be seen as an enabling or limiting aspect. But a transformation is only a success if it is lived and is therefore supported by the corporate culture (Steinhoff, 2018).

Following Steinhoff (2018), the cycle starts with the *strategy,* which includes the corporate goals, positioning, and business model, whereby the scope of a new strategy is set by a vision. A

strategy is used to unlock the potential for success and gain a competitive advantage, but it is influenced by the existing organization. However, if a strategy is changed, it impacts the organization. There is a reciprocal relationship (Steinhoff, 2018). In addition, a change only takes place if there is a sense of urgency (Kotter, 2007). Once this is the case, a change in strategy that is not oriented toward the existing organization can take place, and a transformation is possible (Steinhoff, 2018).

Adapting the strategy to the changed business environment has a direct impact on the *processes*. It requires a fundamental analysis of the value chain. This involves individual steps and their effects on the processes, which include leadership as well as primary and supporting activities of value creation (Steinhoff, 2018). Primary activities are those activities that are directly related to value creation, like logistics, operations, marketing, and sales. Supporting activities are those that are necessary to carry out the primary activities, for example, firm infrastructure, human resource management, and procurement (Porter, 2001). The process changes lead to the emergence and modification of roles along the value chain. Therefore, roles must be redefined and responsibilities determined (Steinhoff, 2018).

The *organization* encompasses the sum of all planned and goal-oriented measures of organizational design (Bea & Haas, 2016). A distinction can be made between organizational structure and process organization. The organizational structure is the static system of a company's organizational units, which regulates the responsibilities for the division of labor in fulfilling the company's tasks (Schewe, n.d.). Process organization, on the other hand, is the space-time aspect of the organization. The organizational elements must be designed regarding the temporal and spatial sequence in such a way that all work processes are seamlessly coordinated (Schewe, n.d.).

Every organization only works as well as it has the right *people*. According to Steinhoff (2018), each person has different skills and competencies, and with their different values and norms, people are a critical success factor in any transformation. It also requires employees who can implement the initiated transformation. The ever-increasing economic dynamics and technological change mean that employees' knowledge quickly becomes obsolete. A decision must therefore be made whether new employees should be recruited or existing employees should continue to develop. Depending on the decision, recruitment or further training measures must be implemented (Steinhoff, 2018).

Systems and tools, according to Steinhoff (2018), refer to methods and information systems that support the transformation. These include IT infrastructure, business applications, and operating resources such as production facilities.

Following Steinhoff (2018), finally, a transformation also results in an adjustment of management and supervision. Corporate *governance* encompasses numerous aspects, such as laws, guidelines, decision-making processes, controls, and incentive systems. It pursues the goal of limiting opportunistic behavior by stakeholders through clear regulations. Measures for monitoring compliant behavior within the company are covered by the term compliance as part of corporate governance. This includes legal as well as ethical and moral requirements that oblige companies to conduct their business following the law. Even though governance is at the end of the transformation cycle, it is of high relevance (Steinhoff, 2018).

The following work is the first to apply the Enterprise Transformation Cycles in the context of sustainability and to show how companies can implement sustainable production in the company.

3. Methodology

This work is based on the qualitative methodology of the systematic literature review (SLR). „Systematic reviews are undertaken to clarify the state of existing research and the implications that should be drawn from this" (Feak & Swales, 2009). In this SLR, the results of existing studies are summarized, compared, and then presented according to the research questions. A methodical-formal approach, as seen in *Figure 3,* is taken as a basis to reduce a selective choice of literature and the associated bias as well as to ensure reliability (Tranfield, Denyer, & Smart, 2003).

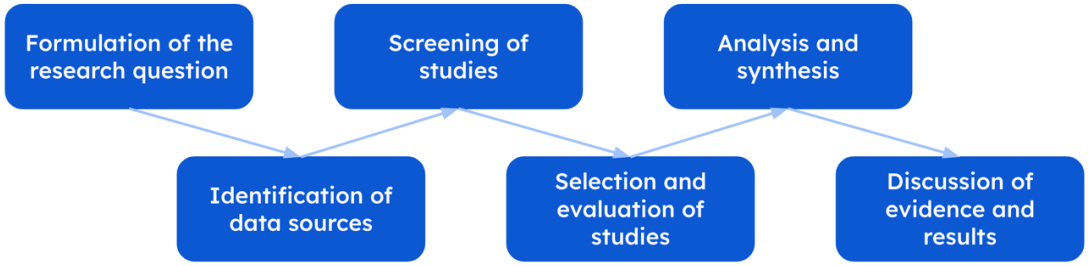

Figure 3: Systematic Literature Review Process based on Tranfield, Denyer, and Smart (2003)

In the field of business studies, the CIMO scheme, according to Denyer & Tranfield, 2009 can be used to formulate a research question that is clear and feasible (Briner & Denyer, 2012; Denyer & Tranfield, 2009). According to this, four criteria should be considered, namely context, intervention, mechanisms, and outcomes. The context indicates which subject or institutional system is being examined. This work examines the European fashion industry. The intervention shows which effect, action, or activity is being investigated. The intervention, in this case, is the switch to sustainable production. Mechanisms illustrate the relationship between the intervention and the outcomes. The transformation itself, including the operational and organizational practices, is considered here. Outcomes show the effects of the intervention. CO2 emissions and value creation are the indicators for the outcomes. The following research question therefore arises: *How can European fashion companies transform towards sustainable production to lower their CO2 emissions and create value?*

Literature databases are essential for the research in SLRs to minimize bias through selective literature selection. The library catalog of Católica Lisbon School of Business & Economics based on EBSCO Discovery Service, which refers to other databases and directories, was used. Databases such as EBSCO, ScienceDirect, Scopus, JSTOR, and Directory of Open

Access Journals were used. To reduce publication errors, not only scientific journals but also gray literature is considered. Publications that are not controlled by the commercial publishing industry are considered gray literature (GLISC, 2007).

The search terms were defined by breaking down the research topic into three equally important blocks of terms, namely sustainability, production, and fashion industry. This approach is also known as the block-building method (Guba, 2008). The topic blocks and search terms, as well as the corresponding synonyms and sub-keywords, can be taken from the term matrix.

Table 1: Search Terms

Keywords	Synonyms & Sub-Keywords
Sustainability	Corporate Social Responsibility; Responsible Business; Corporate Responsibility; Stakeholder; Environmental Performance
Production	Manufacturing; Supply Chain; Circular Economy
Fashion Industry	Apparel industry; Textile industry; Garment industry; Clothing industry; Slow fashion; Fast fashion

Some sources could be identified by searching backward through relevant publications. This involves examining the references of a publication. A literature management program was used to merge all hits from the various databases. Duplicates were deleted in the process. The publications identified using the search terms were evaluated based on defined inclusion and exclusion criteria. During this process, the title, abstract, and keywords were checked. The remaining articles were then read in full and analyzed. It has been checked that journal articles, at best, bear the peer-reviewed label, meaning that the articles have been reviewed and approved for publication by experts in the field. This is the case for 13 journal articles that were included in this work.

The inclusion and exclusion criteria help to find the relevant publications for this work. Only sources in English or German were considered to ensure that the studies can be fully understood and do not need to be translated. In addition, only publications from 2012 onwards were used, as older studies no longer reflect the current state of technical possibilities in a meaningful way. No restriction was placed on the methodology used in the studies. To do a sufficient answer to the research question, care was taken to ensure that the studies considered either European fashion brands or manufacturing companies in Europe or Asia. Asia plays an important role here and must be included, as a large proportion of the fashion produced by European fashion brands comes from this region of the world. In addition, the value chains are

highly globalized, so upstream value creation steps that take place in Asia are included in the analysis. As the focus of this work is on sustainable production, this becomes an inclusion criterion as well as the supply chain when production is covered as a step. Only publications that covered environmental sustainability and CO2 emissions were considered. Social sustainability is not considered in this paper.

Table 2: Criteria for Inclusion and Exclusion of Literature

Inclusion Criteria	Exclusion Criteria
Sources in English or German	Sources in another language
Publications from the year 2012 onwards	Publications before 2012
Qualitative and Quantitative publications from scientific journals and gray literature	Newspaper articles, books, and monographs
Fashion industry with a focus on European fashion brands or Asian manufacturers	Fashion industry with no focus on European fashion brands or Asian manufacturers
Sustainability in production; production as part of the supply chain	No direct reference to sustainability in production
Focus on environmental sustainability and CO2 emissions	No focus on environmental sustainability and CO2 emissions

Finally, 18 sources proved to be suitable for this work. In the following analysis, studies and reports that highlight sustainable production in the fashion industry and related organizational development are examined. The results are then filtered and systematized. The aim is to provide a systematic overview of what practices are already available to companies today and how companies can implement them.

4. Results

4.1 Key Drivers for the Transformation towards Sustainable Production

Most of the studies identified internal and external drivers that are pushing the fashion industry to adopt sustainable production practices. A detailed overview in tabular form is provided in Appendix A.

4.1.1 Internal Drivers

Diabat et al. (2014) indicated that identifying the key drivers and enablers helps implement sustainability effectively. They found internal drivers like the adoption of green purchasing, hazard management, improvement of product characteristics, eco-design, environmental cost, and adoption of safety standards, among others. Notably, green purchasing was identified as the most important driver since production starts with the procurement of raw materials. The study also found employee-related and non-employee-related drivers, underlining the role of employee involvement in achieving environmental goals. Employee-related factors cover employment stability, health and safety issues, community economic welfare, adoption of safety standards, and adoption of green practices. However, these enablers vary depending on the culture and regulations of the country (Diabat et al., 2014).

Moretto et al. (2018) identified the importance of good employee relations, while Pedersen and Andersen (2015) highlighted management commitment and the direct influence of employees on management for successful sustainability implementation, noting that both leadership and employee contributions are essential. Employees themselves have become aware of the high environmental costs (Roland Berger, 2022). Nevertheless, Claxton and Kent (2020) concluded the limited influence of fashion designers on sustainability practices in the current fashion system, suggesting an integration of them into more strategic roles.

Pal and Gander (2018) reported a growing awareness on the corporate side of the environmentally damaging consequences of fashion production, thus promoting new, more sustainable production models. Moreover, compliance with regulations moved from brand protection to a strategic element of business operations (Pui-Yan Ho & Choi, 2012), while internal ethics and commitment, among others, belong to the main drivers to implement sustainable production practices (Moretto et al., 2018). In addition, Yang and Jang (2020) revealed that organizational values have an impact on sustainable activities and the associated positive financial

performance. Regarding competitive advantages, Nguyen et al. (2020) found that sustainability can contribute to a good image and reputation and help to reposition the company on the market. This makes it a driver for adopting sustainability. Finally, Wong and Ngai (2021) concluded that company size affects the prioritization of sustainability. Wholesalers focus on environmental expertise, process innovation, and product development, whereas smaller companies emphasize product development mainly.

4.1.2 External Drivers

Political regulations were often cited as drivers for sustainability activities in companies (Berg et al., 2020; Chen, Memon, Wang, Marriam, & Tebyetekerwa, 2021; Karaosman, Morales-Alonso, & Brun, 2017; Niinimäki et al., 2020; Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015; Roland Berger, 2022; Sadowski et al., 2021). However, Diabat et al. (2014) argued that government regulations have a smaller driving power compared to internal factors because of their strong autonomous nature and may harm innovation in the sector. Nevertheless, they emphasized the need for strict regulation to direct industry adoption of already available practices. Pedersen and Andersen (2015) suggested a system of financial penalties for environmentally harmful materials or scarce resources and tax benefits for sustainable practices. In line with that, Palacios-Mateo et al. (2021) argued that CO2 limits, corporate taxes, the elimination of subsidies for fossil fuels, as well as incentives to switch to regenerative energy and energy-efficient machines can have a strong influence on sustainable production practices. The influence is also evident in the call from governments to transform the textile chain from a linear to a circular economy (Chen et al., 2021).

Customer demands and market pressures were also recognized as significant external drivers (Berg et al., 2020; Diabat et al., 2014; Karaosman et al., 2017; Moretto et al., 2018; Nguyen et al., 2020; Niinimäki et al., 2020; Roland Berger, 2022) while Diabat et al. (2014) noted moderate to high impact of customers influence on sustainable practices. In addition, brands and retailers shape production through sustainable decision-making in the design phase, transparency demands, emissions standards (Berg et al., 2020), as well as circular economy models, and pricing systems reflecting environmental impacts (Niinimäki et al., 2020).

Finally, investors were highlighted as external drivers, with an increasing focus on environmental, social, and governance (ESG) criteria and decarbonization efforts (Berg et al., 2020; Roland Berger, 2022), resulting in more capital flowing to sustainably operating companies (Berg et al., 2020).

4.2 Practices for Sustainable Production

The following chapter shows the sustainable production practices, including benefits and challenges that could be identified from the 18 studies examined (see also Appendix B).

4.2.1 Design

The research showed the foundational role of product design in sustainable fashion production. Studies highlighted the importance of selecting design and production methods that prioritize material efficiency (Claxton & Kent, 2020; Karaosman et al., 2017; Niinimäki et al., 2020; Pal & Gander, 2018; Palacios-Mateo et al., 2021; Pui-Yan Ho & Choi, 2012; Sadowski et al., 2021; Saha et al., 2021; Wong & Ngai, 2021; Yang & Jang, 2020). Some publications presented implementation through digital tools to reduce cut-out pieces (Palacios-Mateo et al., 2021), cradle-to-cradle design principles (Karaosman et al., 2017), or design management audit tools (Claxton & Kent, 2020). Innovative design approaches have been identified as effective in reducing fabric waste and minimizing CO2 emissions (Niinimäki et al., 2020).

Furthermore, there was consensus to design garments in such a way that they can be easily reused or recycled (Nguyen et al., 2020; Palacios-Mateo et al., 2021), with recommendations to avoid material blends to facilitate recyclability (Palacios-Mateo et al., 2021). However, Salmi and Kaipia (2022) presented a differentiated view on fiber blends, increasing the durability and usability. Other studies instead advocated high-quality materials for durable clothing (Claxton & Kent, 2020; Niinimäki et al., 2020; Pal & Gander, 2018; Palacios-Mateo et al., 2021), which also allows for higher retail prices (Claxton & Kent, 2020). Finally, this requires fundamental changes in the industry (Niinimäki et al., 2020).

Salmi and Kaipia (2022) emphasized the importance of education and training of designers in this context, while Pedersen and Andersen (2015) pointed out the benefits of equipping designers with tools for informed material and process selection. Stronger cooperation between design and manufacturing towards a sustainable, low-waste design approach was suggested by Niinimäki et al. (2020). The crucial role of sustainability considerations from the beginning of product design was also confirmed by Karaosman et al. (2017), who found that such concerns are essential for mitigating environmental impacts during a product's life cycle. In addition, they indicated that the use of materials such as organic cotton and other environmentally friendly resources is central to eco-design practices.

4.2.2 Materials

The literature revealed that prioritizing sustainable materials is a key factor in promoting environmentally friendly fashion production (Chen et al., 2021; Claxton & Kent, 2020; Karaosman et al., 2017; Moretto et al., 2018; Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022; Sadowski et al., 2021; Saha et al., 2021; Salmi & Kaipia, 2022; Wong & Ngai, 2021). Such materials include organic cotton (Karaosman et al., 2017; Sadowski et al., 2021), recycled polyester (Palacios-Mateo et al., 2021; Sadowski et al., 2021), as well as renewable, biodegradable fabrics (Chen et al., 2021; Sadowski et al., 2021), and plant-derived alternatives to traditional leather (Sadowski et al., 2021). However, recycled materials are not widely available (Claxton & Kent, 2020) and are generally of poorer quality compared to virgin materials (Claxton & Kent, 2020; Salmi & Kaipia, 2022). Therefore, the selection must weigh quality, cost, and environmental impact (Saha et al., 2021). This is in line with Moretto et al. (2018), who showed the assessment of the sustainability potential in terms of benefits, costs, and effort.

Berg et al. (2020) provided evidence that the use of sustainable materials can reduce upstream emissions. Sadowski et al. (2021) confirmed this argument, stating that careful design, material selection, and manufacturing processes can lead to significant efficiency gains in material use and waste reduction and thus benefit the entire production chain. The increased use of sustainable materials and material substitutions can save a total of 39 million tons of CO2 equivalent. Moreover, increasing the fiber-to-product ratio by ten percent across all types could reduce emissions by 24 million tons of CO2 equivalent. However, the potential for reducing emissions through sustainable materials depends on their rate of introduction (Berg et al., 2020). Suppliers have very little control over the choice of materials, as they follow the buyer's selection (Saha et al., 2021). Furthermore, challenges exist in material substitution, such as the extensive land required for organic cotton cultivation and the specific use of fibers like polyester in functional clothing (Sadowski et al., 2021). Finally, the price difference between preferred and conventional materials is an obstacle to their widespread use in the industry, as many brands refuse to spend more. Nevertheless, some companies accept cost gaps as part of their sustainability commitment by creating centralized funding pools to offset the higher costs (Sadowski et al., 2021), as sustainable products enable price differentiation (Yang & Jang, 2020).

Research by Karaosman et al. (2017), Nguyen et al. (2020), Pedersen and Andersen (2015), and Sadowski et al. (2021) highlighted the development and investment in innovative materials for

production to close the innovation gap and further cut emissions (Sadowski et al., 2021). Moreover, brands' commitment to buying new materials can support the spread whereby purchase agreements secure liability in advance (Sadowski et al., 2021).

Approaches to improve material sourcing include conservation tillage (Sadowski et al., 2021) and broader efficiency improvements in the production, preparation, and processing of raw materials (Berg et al., 2020). Several other studies mentioned the use of naturally derived dyes (Chen et al., 2021; Claxton & Kent, 2020; Palacios-Mateo et al., 2021; Saha et al., 2021) or low-temperature synthetic dyes in single big batch dyeing processes (Chen et al., 2021) as steps towards reducing environmental impact.

4.2.3 Energy

The studies examined documented several strategies for increasing energy efficiency in production facilities (Claxton & Kent, 2020; Sadowski et al., 2021; Saha et al., 2021; Yang & Jang, 2020) through improvements in machinery (Berg et al., 2020; Chen et al., 2021), lighting (Moretto et al., 2018; Pui-Yan Ho & Choi, 2012), heating, insulation, cooling (Moretto et al., 2018), and ventilation systems (Berg et al., 2020; Moretto et al., 2018). Such enhancements in energy efficiency can lead to significant cost savings in the fashion industry (Berg et al., 2020). Pui-Yan Ho and Choi (2012) reported cases in which recycling steam and upgrading to energy-efficient lighting and cooling systems reduced electricity consumption by up to 80%.

Sadowski et al. (2021) showed the potential to reduce energy consumption in tiers one to three of manufacturing by increasing efficiency, whereby the extent of reduction depends on the specific facilities and processes. Specifically, energy and emissions savings of 15% per unit could result in a reduction of 64 million tons of CO2 equivalent emissions between 2019 and 2030. Although energy efficiency is a crucial step because it is an accessible measure with a positive return on investment, the transition to 100% renewable energy is essential to mitigate the increase in absolute CO2 emissions as production increases.

Eight studies noted the use of 100% renewable energy as a key strategy to drastically reduce CO2 emissions (Berg et al., 2020; Chen et al., 2021; Niinimäki et al., 2020; Palacios-Mateo et al., 2021; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022; Sadowski et al., 2021; Saha et al., 2021), with the potential of up to 424 million tons (Sadowski et al., 2021). However, the switch to renewable energy is capital-intensive and has little short-term effect and therefore requires financial incentives (Saha et al., 2021). Power purchase agreements (PPAs) were suggested as a solution for

this transition, but PPAs are not available in all production regions, such as Turkey and Bangladesh (Berg et al., 2020). Furthermore, the phase-out of coal as a source of thermal energy was mentioned by switching from coal-fired boilers to electric boilers (Berg et al., 2020; Sadowski et al., 2021). Half the coal in tiers one and two replaced with carbon-free sources could decrease emissions by 105 million tons of CO2 equivalent (Sadowski et al., 2021).

4.2.4 Processes

The literature showed the importance of waste reduction and improving waste management (Chen et al., 2021; Moretto et al., 2018; Niinimäki et al., 2020; Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022; Sadowski et al., 2021; Saha et al., 2021; Salmi & Kaipia, 2022; Wong & Ngai, 2021; Yang & Jang, 2020). Reuse strategies include returning fabric cut-outs to the value chain, marketing recycled waste (Saha et al., 2021), and upcycling pre- and post-consumer waste (Pedersen & Andersen, 2015). Reusing materials in their original form, such as clothing packaging, and sewing needles (Wong & Ngai, 2021), and improving waste disposal protocols (Moretto et al., 2018) were also suggested. The study by Saha et al. (2021) emphasized the improvement of quality control measures that contribute to the longevity of products and the reduction of waste.

Textile recycling was mentioned by 12 studies (Berg et al., 2020; Chen et al., 2021; Claxton & Kent, 2020; Nguyen et al., 2020; Niinimäki et al., 2020; Pal & Gander, 2018; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Sadowski et al., 2021; Salmi & Kaipia, 2022; Wong & Ngai, 2021; Yang & Jang, 2020) as a key process for improving sustainability in production, while Chen et al. (2021) mentioned solvent technologies as a method for textiles recycling. However, Claxton and Kent (2020) stressed the lack of scalable and efficient processes and aesthetic constraints of textile recycling. Finally, the processes must be embedded across the global supply chains to enhance recycling within each tier (Sadowski et al., 2021).

The research referred to the use of specialized software for monitoring and reduction of CO2 (Berg et al., 2020; Moretto et al., 2018; Roland Berger, 2022; Sadowski et al., 2021), such as the Higg Facility Environmental Module (Berg et al., 2020). Annual environmental audits (Karaosman et al., 2017; Moretto et al., 2018; Pui-Yan Ho & Choi, 2012; Sadowski et al., 2021), reporting (Moretto et al., 2018; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012) and the acquisition of certifications and labels (Karaosman et al., 2017; Pedersen & Andersen, 2015) were also identified as common practices within the industry to assess and communicate environmental

performance (Karaosman et al., 2017; Moretto et al., 2018). Furthermore, the introduction of holistic life cycle models for garments (Niinimäki et al., 2020), including life cycle assessment (LCA) (Karaosman et al., 2017; Moretto et al., 2018), was documented to measure the environmental impact. Another focus is improving transparency (Moretto et al., 2018; Nguyen et al., 2020) through the introduction of traceability systems (Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015) like the digitization of material flows using RFID chips (Salmi & Kaipia, 2022).

Ecological practices are not considered uniformly along the value chain (Karaosman et al., 2017). Therefore, training and investment in suppliers play an important role in reducing scope three emissions (Roland Berger, 2022). Moreover, the literature showed a trend toward setting higher environmental standards for suppliers (Nguyen et al., 2020) and introducing systems to assess and monitor suppliers (Karaosman et al., 2017; Moretto et al., 2018). Nevertheless, Saha et al. (2021) noted that CO2 emissions are not yet considered as an environmental criterion for compliance with environmental regulations. However, suppliers advertise compliance with regulations to obtain volume contracts, but the contracts are not profitable due to the high costs.

The concept of circular economy was a recurring topic in the literature, with Chen et al. (2021), Claxton and Kent (2020), and others exploring its application in the industry (Niinimäki et al., 2020; Pal & Gander, 2018; Pui-Yan Ho & Choi, 2012). Yet, further innovations in textile recycling are required to promote the circular economy (Niinimäki et al., 2020).

Strategies to reduce overproduction including the offer of permanent collections (Niinimäki et al., 2020), slow fashion principles (Pedersen & Andersen, 2015), and on-demand production (Pal & Gander, 2018; Roland Berger, 2022; Salmi & Kaipia, 2022; Yang & Jang, 2020), were discussed to better adapt production volumes to demand (Roland Berger, 2022). However, short lead times required by the industry were identified as an obstacle (Claxton & Kent, 2020). But, in one case it was therefore possible to reduce stock levels, minimize the risk of outdated products, and respond more quickly to customer requests (Salmi & Kaipia, 2022).

Berg et al. (2020) highlighted the substantial impact of decarbonizing upstream operations through energy efficiency, renewable energy, and general efficiency improvements, leading to a GHG reduction of 205 million tons in material production, 703 million tons in material processing, and an additional 90 million tons reduction in garment manufacturing annually. Furthermore, Sadowski et al. (2021) estimated that such measures could deliver over 60% of the required reductions to reach the 1.5°C target. Besides positive environmental effects, clean processes may

increase production costs, which could lead to an economic decline in the fashion industry (Niinimäki et al., 2020). However, the application of sustainable practices can lead to competitive advantage for companies through new knowledge and skills (Wong & Ngai, 2021). Pui-Yan Ho and Choi (2012) described a case in which switching from traditional batch flow to a one-piece flow system led to a 30% increase in cost efficiency and less waste within one year. In addition, Berg et al. (2020) describe the economic benefits of reducing waste and scrap and minimizing the use of fertilizers and pesticides in cotton production as key strategies for reducing costs and increasing sustainability. Finally, Berg et al. (2020) found that most GHG reduction actions are cost-effective, with about 90% achievable at approximately US$ 50 per ton and 55% leading to industry-wide cost saving, but some require incentives, regulation, or significant collaborative investments for long-term benefits. Carbon offsetting activities (Saha et al., 2021) and carbon capture (Karaosman et al., 2017) were proposed for remaining emissions that cannot be prevented directly by measures.

4.2.5 Organizational

Moretto et al. (2018) emphasized the need to revise not just operational procedures but also organizational structures to embed sustainability practices effectively. This requires a new governance management system to ensure that the organizational structure is in line with the new business approach, recognizing the interconnectedness of operational and organizational practices.

In line with this, the review identified several organizational strategies that support the fashion industry's transformation to environmentally sustainable production, such as circular business models that focus on closed-loop production (Berg et al., 2020; Niinimäki et al., 2020; Sadowski et al., 2021; Salmi & Kaipia, 2022). However, the lack of scalability, obstacles in the supply chain (Pal & Gander, 2018), and requirements of economic growth (Berg et al., 2020) could prevent the adoption of these models. The challenges are anchored in the current business models and consumption habits of fast fashion (Pedersen & Andersen, 2015). Established apparel companies are limited by three factors in the shift to a circular economy, namely product orientation, the existing product portfolio, and the position in the supply chain (Salmi & Kaipia, 2022). Lastly, the high financial pressure and competitiveness of the fashion industry were noted, which makes it difficult to change business practices (Niinimäki et al., 2020).

Sadowski et al. (2021) stressed the importance of science-based targets as a strategic approach for the industry to commit and reduce its environmental impact. Similarly, studies

addressed the issue of quantifiable and verifiable emission reduction targets (Berg et al., 2020; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022). Furthermore, the alignment of financial key performance indicators (KPIs) with decarbonization targets (Roland Berger, 2022), as well as the harmonization of financial incentives (Berg et al., 2020), was recognized as an effective strategy to support sustainability goals.

It was noted that suppliers may not be able to make their changes due to a lack of knowledge or because new sustainability improvements require significant investment (Moretto et al., 2018). Saha et al. (2021) found high fixed costs for environmental compliance and modernization costs that amount to 15% of the costs of new factories. Even low-interest loans from institutions such as the World Bank already require environmental compatibility. Companies experience tougher competition if they do not meet this requirement, as they receive fewer production orders or can only work as third-party suppliers with a lower profit margin (Saha et al., 2021). Thus, collaborative upfront investments in sustainable technologies and processes are necessary to share risks and benefits (Berg et al., 2020; Palacios-Mateo et al., 2021).

Effective communication with suppliers (Saha et al., 2021), stakeholder engagement (Karaosman et al., 2017; Nguyen et al., 2020; Pui-Yan Ho & Choi, 2012), and partnership building (Berg et al., 2020; Moretto et al., 2018; Yang & Jang, 2020) were identified as key elements in promoting a collaborative approach to sustainability. In addition, developing a robust knowledge base for environmental management (Saha et al., 2021), creating platforms for sustainability experiences and best practices (Pedersen & Andersen, 2015), and sharing knowledge in sustainability management along the entire value chain (Karaosman et al., 2017; Saha et al., 2021) were found to be essential. However, supply chain transformation is complex, as processes are spread across various players and locations (Salmi & Kaipia, 2022).

The literature showed that training employees in sustainable practices is crucial to driving environmentally sustainable production, providing employees with maintenance and servicing skills to extend the life of machinery, as well as the knowledge of efficient facility management and space utilization (Saha et al., 2021). In addition, the development of organizational capabilities (Karaosman et al., 2017), especially sensing, seizing, and transformation capabilities, as highlighted by Salmi and Kaipia (2022), is critical for change toward sustainability. Wong and Ngai (2021) stressed strategic resource alignment and sustainability expertise to improve competitiveness and market survival by focusing on developing organizational, environmental, and

economic competencies. They further identified the effective implementation of the five R – reduce, reuse, recycle, recover, and redesign – to promote business sustainability competence, which is linked to enhanced sustainability and firm performance. These findings indicate a direct link between a firm's capabilities and its market performance (Wong & Ngai, 2021).

Pedersen and Andersen (2015) found that current sustainability efforts are not enough to address key environmental challenges. Initiatives of large fashion companies often focus on small improvements rather than fundamental organizational changes. Therefore, sustainable leadership (Nguyen et al., 2020) and management commitment (Pedersen & Andersen, 2015) were emphasized as being key. Nguyen et al. (2020) highlighted the challenge of promoting sustainable leadership in emerging markets due to limited experience and professionalism and noted its potential to enhance corporate reputation, customer loyalty, and competitive positioning.

Strategic environmental management, emphasizing product development, responsibility across product life cycles (Pui-Yan Ho & Choi, 2012), and first-mover advantages (Roland Berger, 2022; Salmi & Kaipia, 2022) are competitive strategies for gaining market leadership. First market access can lead to a faster return on investment than companies that follow, as latecomers have less time to initiate and just imitate (Pui-Yan Ho & Choi, 2012). Downstream positive economic effects of sustainably produced products were identified by Karaosman et al. (2017), namely, product differentiation as a competitive strategy through emotional appeal to the consumer via the branding, identity, and creative concept of sustainable products. Yang and Jang (2020) found that the financial success of small and medium-sized fashion companies is strengthened by sustainability management. Whereby organizational values and experiences are crucial for sustainable practices. Therefore, aligning sustainable activities with organizational values is important to increase brand value and bring long-term financial benefits (Yang & Jang, 2020).

Adopting new standards (Moretto et al., 2018; Nguyen et al., 2020), introducing product and process certifications (Karaosman et al., 2017), and formulating self-regulatory mechanisms like ethical standards (Nguyen et al., 2020) were identified as common strategies for promoting environmentally sustainable production practices. Furthermore, the importance of building trust and creating a values-based corporate culture, with a focus on integrating sustainability into the core of the corporate culture, was discussed in several publications (Claxton & Kent, 2020; Diabat et al., 2014; Moretto et al., 2018; Nguyen et al., 2020).

5. Discussion

5.1 Implementation of Sustainable Production

To align with the 1.5°C target, the fashion industry must decouple sales growth from emissions by optimizing products, designing for circular, and adjusting processes and business models (Berg et al., 2020; Sadowski et al., 2021). The current business model of the fashion industry can be identified as an inhibiting factor. Although solutions for sustainable production exist from a technical point of view, adapting isolated measures is not enough. Fundamental organizational changes are needed that go far beyond operational practices to facilitate the way to sustainable production. Responsibility lies not only with the upper management of apparel brands but also with relevant stakeholders that support the current system, including suppliers, designers, and customers. A fashion industry transformation demands a restructuring of the structure, organization, and administration of fashion companies with no one-size-fits-all model (Pedersen & Andersen, 2015). The implementation of sustainability is not a static approach but develops over time for the company (Moretto et al., 2018). As long-term economic effectiveness depends on the way of implementation of sustainability (Nguyen et al., 2020), companies need holistic approaches. The steps, instruments, and competencies required for this were highlighted by various studies and reports and, with the help of the Enterprise Transformation Cycles, are now translated into an actionable form for companies.

5.1.1 Strategy

The internal and external drivers presented show how they can push companies to consider the issue of sustainable production as urgent and thus contribute to change. Factors such as consumer demand, investor pressure, and the legal framework can be catalysts for a reassessment of strategic priorities to incorporate CO2 reduction and value creation at the same time. In particular, the setting of emission reduction targets by SBTi is of crucial importance to set the company on an emission reduction path. Moreover, a design that focuses on material efficiency and the reduction of CO2 emissions can be a strategic cornerstone for environmental sustainability. Durable products made from high-quality materials would indicate a strategic move away from fast fashion to more sustainable business models (Claxton & Kent, 2020; Niinimäki et al., 2020).

It is noticeable that the practices differ in their strategic scope. A strong sustainability strategy puts environmental value at the center of operations and makes it one of the key

performance measures. This changes the way a company conducts its business and creates value. In contrast, a weak sustainability strategy does not aim to challenge the profit motive and primary performance sources of the company. Even if the environmental performance is increased, the role is secondary and does not aim to fundamentally change the business (Pal & Gander, 2018). Activities that are in the material and manufacturing phase are more likely to be considered as an improved business-as-usual approach other than sustainability activities that move toward a circular approach to production and focus on the entire product life cycle (Claxton & Kent, 2020; Pedersen & Andersen, 2015). For example, the adoption of reuse and recycling methods can either enhance existing production systems or fundamentally transform them into circular business models, where such practices are central to value creation.

The strategic shift appears to be driven by the recognition of sustainability as a competitive advantage, contributing to improved brand image and reputation, as noted by Nguyen et al. (2020). Companies can use sustainable practices not just for compliance or branding but as a strategic differentiator that offers long-term value. Therefore, companies must assess their market position, target market, and whether they have the resources to do so. Where competitive advantage through price and quality is not achievable, strategies of differentiation are still to be considered. Consumers can be emotionally addressed by the brand image and the creative concept of sustainable products (Claxton & Kent, 2020). Moreover, companies that adopt strategic approaches to environmental management can gain a first-mover advantage, leading market trends and securing a dominant market position. This approach would not just be an environmental commitment but a strategic business decision that can lead to long-term success.

The integration of employee environmental awareness and management commitment indicates a bottom-up approach to sustainability that requires a strategy that includes both leadership and employee involvement, which is consistent with Pedersen and Andersen (2015).

In summary, companies must first set dual targets for CO2 reduction and value creation. Then, strategic priorities must be set, which divides the goal into action areas for the company, like innovation, communication, performance evaluation, stakeholder engagement, and impact reduction, which is in line with Karaosman et al. (2017). Finally, this is followed by practices that contribute to the goal. The mere adaptation of sustainable practices is not enough to be ecologically and economically successful in the long term. Therefore, sustainability transformation requires a holistic and strategic approach by incorporating sustainability into their core business models.

5.1.2 Processes

The process dimension includes all operational practices in the value chain that are in line with reducing CO2 emissions in fashion production. This involves a radical change of the existing value chain, from design to disposal, embedding sustainability at every stage to optimize for efficiency, waste reduction, recyclability, and minimal environmental impact. Therefore, companies must analyze the value chain to understand the direct and indirect effects of each step, from the procurement of materials to the manufacture of fashion goods. The transition to more sustainable materials such as organic cotton or recycled polyester is an important focus area despite the challenges of scalability and integration into existing processes. The switch to energy efficiency in production facilities, including the introduction of machines and systems that reduce energy consumption and the increased use of renewable energy sources, has a major leverage effect that not only benefits the environment but also brings cost savings in the long run. In general, most practices require a long-term view to realize economic advantages, although ecological benefits are already being achieved in the short term.

5.1.3 Organization

The organization dimension of the ETC underlines the central role of structure and process organization as well as the new distribution of roles for the successful execution of transformations. This aligns with findings that stress the need for revising the organizational structure to integrate sustainability practices effectively. It should lead to a management system supporting the sustainability strategy. The studies illustrate that companies can successfully optimize their workflows for sustainable production, leading to reduced resource consumption through better planning, control, and production methods.

Establishing new positions and departments, such as sustainability management, is essential for coordinating sustainability objectives, which may result in a reshaping of the corporate culture and organization. Although challenges like adapting the new positions to existing structures and overcoming resistance to change may arise, cross-functional cooperation and sustainability outcomes can be improved. Enhanced cooperation between different departments and teams to integrate sustainability goals into the value chain is indispensable. This also includes cooperation between design and manufacturing as well as external collaboration with NGOs, government, suppliers, and partners along the tiers. Moreover, sustainability committees, where representatives from all corporate functions, including design, gather to discuss and set the agenda, could be

important to achieve institutionalization. This promotes embedding sustainability in the company culture and integration of tasks (Claxton & Kent, 2020).

The introduction of circular business models represents the most far-reaching consequences for the organizational structure, but at the same time, it has the most strategic character and the greatest ecological impact. However, obstacles such as scalability, supply chain barriers, and the demands of economic growth could hinder the widespread adoption of these models.

5.1.4 People

The results clearly show that sustainable change depends heavily on the people in the company. The active involvement of employees, from the factory floor to the boardroom, is fundamental. A collective effort must be made to align employees' values and norms with the company's sustainability goals, which can be achieved through training, incentives, and transparent communication. Employees and managers must be sensitized to the importance of sustainability, ensuring that it becomes an integral part of value creation and the new business approach.

New tasks and responsibilities mean that employees must acquire the skills and knowledge for sustainable practices like sustainable materials and methods. Therefore, companies must evaluate if their current workforce can take on these new tasks or if new, qualified specialists can be recruited. Moreover, sustainable leadership and management commitment are essential for the effective implementation of sustainability. Company leaders must provide clear direction and resources for sustainability initiatives. That makes it even more necessary to overcome the challenges of establishing sustainable leadership, especially in emerging markets.

5.1.5 Systems & Tools

The findings highlight the importance of digital tools and technologies in promoting sustainable production by enabling certain practices, improving production processes, or helping with collaboration across tiers. In particular, the use of data management and analytics can help to monitor and improve the environmental performance of both the factory and its suppliers. Moreover, measuring key sustainability metrics plays an important role in the decision-making of the management. Systems that support circular economy models, such as sustainable supply chain management and product lifecycle management software, enable a shift to circular practices by managing resources more efficiently and reducing waste. Technologies also enable digital platforms for collaboration between different stakeholders, including designers, manufacturers,

and suppliers, which increase the transparency that is essential for sustainable production. In addition, they are important tools for training employees in sustainable practices. Finally, a key measure is to create a system for identifying and tracking GHG reduction targets throughout the value chain and to report regularly on the progress made. This requires transparency at all stages (Roland Berger, 2022). Of course, challenges remain in implementing these systems as they involve high initial investment but promise long-term sustainability and business growth.

5.1.6 Governance

Organizational practices emphasize the need for corporate governance and compliance for the integration of sustainability. Operational and organizational practices are interconnected and therefore require new governance and management systems to harmonize organizational structures with the sustainability strategy (Moretto et al., 2018). Corporate governance in the fashion industry requires a shift from defensive and compliance to a more strategic, sustainability-focused approach.

The influence of government regulations and political measures are important drivers of change that place various legal and ethical requirements on companies. This increases the importance of governance standards extending beyond legal compliance to also meet the ethical and moral expectations of stakeholders like consumers and environmental groups. A governance system focused on transparency and accountability is essential to ensure that companies are responsible not only to shareholders but also to a wider group of stakeholders. Involving different stakeholders in the governance process is consistent with ETC's view of governance, which sees collaboration both inside and outside the organization to ensure that all relevant voices are heard and considered in decision-making.

Sustainability in products demands its integration into production processes and environmental standards for these processes, including involvement and evaluation of first-tier suppliers with ecological criteria. Implementing supplier evaluation systems and audits ensures environmental performance in production and can lead to better risk management and sustainability monitoring.

The findings indicate the need for incentive systems embedded in governance structures to drive change toward environmentally sustainable practices. The challenge is to align the incentives with those involved so that they have a motivating effect and do justice to the different interests within the industry. However, implementing governance structures that not only comply with external regulations but also effectively drive internal change towards sustainability faces

challenges, including traditional corporate cultures and resistance to change. Another critical aspect is the balance between short-term business objectives and long-term sustainability goals. Governance in the context of ETC should ideally facilitate this balance, but the results point to a tension where immediate financial returns often take priority over long-term environmental goals. This highlights the need for governance structures that can adjust these potentially conflicting objectives.

The dynamic nature of governance, as described in the ETC, suggests a continuous process of adaptation and improvement. However, the results show that many companies in the fashion industry are still at the beginning of this process. The challenge is to go beyond the first steps and develop governance systems that are fully integrated and adaptable to drive sustainable change. As the fashion industry continues to evolve, effective governance will be key to ensuring that sustainability becomes a central part of corporate strategy and operations, driving long-term value creation and environmental responsibility. Consequently, there is an important reciprocal relationship between governance and the strategy that frames this transformation.

5.1.7 Values & Principles

Values and principles play a crucial role in guiding organizational change toward sustainability. This is in line with the ETC, which places values and principles at the center, influencing all other dimensions of organizational change. The results indicate that corporate culture, which is deeply rooted in certain values and beliefs, can act as a driver for sustainable change. This culture, characterized by a commitment to environmental stewardship and ethical practices, drives the adoption of sustainable production methods. Therefore, it can be said that values and principles shape strategic decisions and operational practices in the fashion industry. Companies with a strong emphasis on sustainability values are more likely to adopt practices that reduce environmental impact and promote environmental standards.

One challenge can be the diversity of corporate cultures and values in different organizations and regions, which impacts the way sustainability is dealt with. This diversity therefore requires tailored strategies to effectively embed sustainable practices in different organizational contexts.

It becomes clear how important it is to involve employees and other stakeholders in the sustainability process. Companies that successfully engage their employees and stakeholders in their sustainability values tend to have more effective change. Therefore, companies should

promote and strive for a corporate culture that actively supports sustainable practices by ensuring alignment between stated values and actual business practices.

5.2 Theoretical Implications

This thesis offers important theoretical implications that contribute to the understanding of sustainability in the European fashion industry. The findings reposition sustainability as an integral part of strategic business processes in fashion production. Despite short-term implementation challenges, it shows that long-term value can be created, underlining the business case for action. The novel application of the ETC to sustainability transformation in fashion companies extends the scope of the framework beyond digital transformation. This demonstrates the potential of the ETC as a structured approach to managing sustainability transformation and offers a new perspective on implementation within the company.

This work supports the theoretical understanding by identifying how internal and external drivers influence corporate sustainability strategies. They underline the need for a holistic approach to sustainability in the context of stakeholder integration in fundamental change processes. Especially the role of government action highlighted in this paper has implications for environmental policy and corporate governance by emphasizing the importance of political frameworks in guiding corporate sustainability initiatives. Additionally, the findings contribute to organizational theory by demonstrating that the integration of sustainability into organizational structures and cultures requires a change in corporate values, strategy, and practices.

5.3 Practical Implications

The thesis has practical implications for European fashion companies and manufacturers in emerging Asian countries aiming for ecologically sustainable production and CO2 emission reduction. Environmental sustainability, strategically pursued, such as the reduction of CO2 emissions, can be a competitive advantage, enhancing a company's success and market positioning. Whereby the ETC framework can act as a tool for these companies to reassess their strategy in response to a changing environmental and regulatory landscape and methodically guide companies through the transformation to sustainable production. This thesis contributes to the discourse by highlighting the importance of organizational and practical changes and provides strategies that can facilitate a successful transformation. It also provides a roadmap for European fashion companies to achieve sustainable production utilizing the ETC. This multidimensional approach includes strategic management, process redesign, organizational restructuring, technological

advances, governance, and cultural change. By integrating these elements with the overall goal of reducing CO2 emissions, companies can create long-term value and contribute to achieving global climate targets.

5.4 Limitations and Research Outlook

While this work provides a comprehensive overview of sustainable practices in the fashion industry, its primary focus on European fashion companies and Asian manufacturers may not fully capture the global differences in sustainable practices. Different regions and actors bring unique challenges that could further expand the understanding of sustainable transformation. Thus, there is a need for further research on specific roles and tasks of fashion companies and manufacturers in various regions to optimize the effectiveness of sustainability transformation.

The use of literature from 2012 to 2022 limits the historical perspective. Earlier studies could provide insights and explain the development of sustainability practices and previous challenges. Additionally, while the qualitative analysis provides depth, the inclusion of more quantitative data could offer more detailed perspectives, especially when measuring the impact of sustainable practices on CO2 emissions and value creation. This gap opens opportunities for further research and development of impact accounting.

Further limitations of this work originate from the use of existing publications and studies. Some findings, particularly from case studies and interviews, may not be generalized across other companies. Moreover, assumptions made in some studies may reduce the accuracy of the information. This is especially true for the estimates of the emissions saved by the various practices. In terms of changes in CO2 emissions and economic impact, long-term studies would be required to better monitor the impacts of sustainability initiatives over time.

Since government regulation was mentioned as one driver for implementation, future research could explore government actions that incentivize sustainable production, especially where there is no direct economic incentive. In addition, this thesis may not capture all the challenges faced by companies of different sizes. Investigations are therefore needed to address the unique characteristics of different company sizes to identify effective practices and strategies. Finally, cross-industry studies of sustainability transformations could also provide new insights and innovative practices for the fashion industry. Especially research on future innovations is relevant to further explore the possibilities for further emission reductions.

6. Conclusion

This master's thesis examines the paths that the European fashion industry can take towards environmentally sustainable production. The systematic literature review draws on diverse literature to outline strategies, challenges, and benefits.

The central role of circular economy principles, technological advancements, emission reduction targets, and the adoption of preferred materials proves to be essential for reducing emissions. Customer demand, internal stakeholder engagement, and government regulations are identified as important factors driving strategic shifts toward sustainability. While challenges remain, such as overcoming resistance within companies, scalability, and investment in new technologies, the potential for competitive advantage and economic benefits is evident. Practices such as reducing waste, optimizing material efficiency, and using renewable energy sources can lead to cost savings. The variety of available practices gives hope that companies can achieve a substantial reduction in CO2 emissions and create value at the same time.

The existing literature lacks frameworks to support companies in the transformative process of implementing sustainable practices. Through the lens of the ETC, this work offers a structured approach to navigating the challenges of introducing sustainable fashion production. It illustrates that an integrative approach, combining operational and organizational changes, is essential for embedding environmental sustainability in the industry's value chain. This work makes a new contribution by applying the ETC to sustainability efforts in the fashion industry.

Ultimately, the findings call for fashion companies to integrate sustainability at the core of their businesses and use it as a future-oriented business strategy. Companies that do not proactively anticipate this change process and fail to catch up with sustainable production are at risk of losing their competitiveness. At a time when sustainability is not only an ethical obligation but also a competitive mandate, transforming production into a sustainability-driven model is one of the biggest opportunities in the fashion industry.

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Appendices

Appendix A: Internal and External Drivers of Sustainable Production

Driver	Source
Internal Driver	
Adoption of green purchasing, hazard management, improvement of product characteristics, eco-design, environmental cost, employment stability, adoption of safety standards, health and safety issues, community economic welfare, and adoption of green purchasing	(Diabat et al., 2014)
Compliance; compliance with the law	(Claxton & Kent, 2020; Moretto et al., 2018; Pui-Yan Ho & Choi, 2012)
Competitive advantage	(Nguyen et al., 2020)
Organizational values; internal ethics and commitment	(Moretto et al., 2018; Pal & Gander, 2018; Yang & Jang, 2020)
Employees	(Diabat et al., 2014; Moretto et al., 2018; Pedersen & Andersen, 2015; Roland Berger, 2022)
Fashion designer	(Claxton & Kent, 2020)
Size of the company	(Wong & Ngai, 2021)
Management; sustainable leadership	(Pedersen & Andersen, 2015)
External Driver	
Government regulations	(Berg et al., 2020; Chen et al., 2021; Diabat et al., 2014; Karaosman et al., 2017; Niinimäki et al., 2020; Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015; Roland Berger, 2022; Sadowski et al., 2021)
Customers; customer requests; customer satisfaction; market force	(Berg et al., 2020; Diabat et al., 2014; Karaosman et al., 2017; Moretto et al., 2018; Nguyen et al., 2020; Niinimäki et al., 2020; Roland Berger, 2022)
Investors; ESG criteria	(Berg et al., 2020; Roland Berger, 2022)
Brands & retailers	(Berg et al., 2020; Niinimäki et al., 2020)

Appendix B: Practices and Strategies of Environmentally Sustainable Production

Practice for Sustainable Production	Source
DESIGN	
Design methods to maximize material efficiency (such as digital tools to reduce cut-out pieces; cradle-to-cradle design principles; design management audit tool)	(Claxton & Kent, 2020; Karaosman et al., 2017; Niinimäki et al., 2020; Pal & Gander, 2018; Palacios-Mateo et al., 2021; Pui-Yan Ho & Choi, 2012; Sadowski et al., 2021; Saha et al., 2021; Wong & Ngai, 2021; Yang & Jang, 2020)
Education of designers; closer collaboration between design and manufacturing for a low-waste-driven sustainable design–manufacturing–consumption model; tools for designers to make more informed materials and process decisions	(Niinimäki et al., 2020; Pedersen & Andersen, 2015; Salmi & Kaipia, 2022)
Design garments that can be easily reused or recycled; avoid blends to increase recyclability	(Nguyen et al., 2020; Palacios-Mateo et al., 2021)
Work with high-quality materials for durable clothing	(Claxton & Kent, 2020; Niinimäki et al., 2020; Pal & Gander, 2018; Palacios-Mateo et al., 2021)
MATERIALS	

Source materials sustainably e.g., conservation tillage for cotton; efficiency improvements in raw material production, preparation, and processing.	(Berg et al., 2020; Sadowski et al., 2021)
Use and scale sustainable materials (such as recycled polyester, organic cotton, renewable and recyclable materials, bio-based and biodegradable materials, plant-based leather); material selection based on quality–cost–environment criteria	(Chen et al., 2021; Claxton & Kent, 2020; Karaosman et al., 2017; Moretto et al., 2018; Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022; Sadowski et al., 2021; Saha et al., 2021; Salmi & Kaipia, 2022; Wong & Ngai, 2021)
Consider materials other than polyester that are sustainable	(Niinimäki et al., 2020; Palacios-Mateo et al., 2021)
Develop and invest in innovative materials	(Karaosman et al., 2017; Nguyen et al., 2020; Pedersen & Andersen, 2015; Sadowski et al., 2021)
Use of naturally derived dyes or low-temperature synthetic dyes in single big batch dyeing processes	(Chen et al., 2021; Claxton & Kent, 2020; Palacios-Mateo et al., 2021; Saha et al., 2021)
ENERGY	
Expand energy efficiency efforts across manufacturing facilities (including machinery, lighting, heating, insulation, cooling, and ventilation); recycle steam for heating water and powering the cooling system	(Chen et al., 2021; Claxton & Kent, 2020; Moretto et al., 2018; Pui-Yan Ho & Choi, 2012; Sadowski et al., 2021; Saha et al., 2021; Yang & Jang, 2020)
Eliminate coal in manufacturing; switch from coal energy boilers to electric boilers in synthetic material production	(Berg et al., 2020; Sadowski et al., 2021)
Shift to 100% renewable electricity; establish power purchase agreements (PPA)	(Berg et al., 2020; Chen et al., 2021; Niinimäki et al., 2020; Palacios-Mateo et al., 2021; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022; Sadowski et al., 2021; Saha et al., 2021)
PROCESSES	
Reduce waste; improve leftover/waste management; recycle cut-outs back into the supply chain; marketisation of the waste recycling; upcycle pre-consumer and post-consumer waste; reuse (such as garment packaging, dress pins, and sewing needles, in their original form); proper waste disposal	(Chen et al., 2021; Moretto et al., 2018; Niinimäki et al., 2020; Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022; Sadowski et al., 2021; Saha et al., 2021; Salmi & Kaipia, 2022; Wong & Ngai, 2021; Yang & Jang, 2020)
Textile-to-textile recycling (such as solvent technologies)	(Berg et al., 2020; Chen et al., 2021; Claxton & Kent, 2020; Nguyen et al., 2020; Niinimäki et al., 2020; Pal & Gander, 2018; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Sadowski et al., 2021; Salmi & Kaipia, 2022; Wong & Ngai, 2021; Yang & Jang, 2020)
Measure CO2 emissions (such as the use of software to monitor and help lower emissions; tools: abatement cost curves and the Higg Facility Environmental Module)	(Berg et al., 2020; Moretto et al., 2018; Roland Berger, 2022; Sadowski et al., 2021)
Annual environmental audits, reporting, certifications, labels	(Karaosman et al., 2017; Moretto et al., 2018; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Sadowski et al., 2021)
Circular economy	(Chen et al., 2021; Claxton & Kent, 2020; Niinimäki et al., 2020; Pal & Gander, 2018; Pui-Yan Ho & Choi, 2012)
Reduce overproduction; offer permanent collections	(Niinimäki et al., 2020; Roland Berger, 2022)
On-demand production; predict demand	(Pal & Gander, 2018; Roland Berger, 2022; Salmi & Kaipia, 2022; Yang & Jang, 2020)
Train and invest in suppliers to reduce Scope 3 emissions	(Roland Berger, 2022)
Increase transparency; implement traceability through digitalization; digitalization of material flows with RFID chips	(Moretto et al., 2018; Nguyen et al., 2020; Palacios-Mateo et al., 2021; Pedersen & Andersen, 2015; Salmi & Kaipia, 2022)

Implement holistic garment life cycle model/LCA	(Karaosman et al., 2017; Moretto et al., 2018; Niinimäki et al., 2020)
Carbon offsetting activities; carbon capture and storage	(Karaosman et al., 2017; Saha et al., 2021)
Increase quality control; continuous quality assurance	(Saha et al., 2021)
Establish higher environmental standards for suppliers; supplier evaluation systems; supplier monitoring	(Karaosman et al., 2017; Moretto et al., 2018; Nguyen et al., 2020)
Restructure from a traditional batch flow to a more efficient one-piece flow	(Pui-Yan Ho & Choi, 2012)
ORGANIZATIONAL	
New business models; circular business models; slow fashion	(Berg et al., 2020; Niinimäki et al., 2020; Pedersen & Andersen, 2015; Sadowski et al., 2021; Salmi & Kaipia, 2022)
Set science-based targets; set targets on GHG emissions	(Berg et al., 2020; Pui-Yan Ho & Choi, 2012; Roland Berger, 2022; Sadowski et al., 2021)
Align financial and decarbonization KPIs; align financial incentives	(Berg et al., 2020; Palacios-Mateo et al., 2021; Roland Berger, 2022)
Collaborate to finance upfront investments; joint investments	(Berg et al., 2020; Palacios-Mateo et al., 2021)
Knowledge sharing in sustainability management across the value chain; strong communication with suppliers; stakeholder engagement; partnerships	(Berg et al., 2020; Karaosman et al., 2017; Moretto et al., 2018; Nguyen et al., 2020; Pedersen & Andersen, 2015; Pui-Yan Ho & Choi, 2012; Saha et al., 2021; Yang & Jang, 2020)
Develop knowledge and skill base for environmental management; platform for sharing experiences, best practices, and solutions	(Pedersen & Andersen, 2015; Saha et al., 2021)
Training employees in sustainable practices; servicing and maintenance skills to extend the lifespan of machinery; expertise in facility management and space optimization	(Pedersen & Andersen, 2015; Saha et al., 2021; Salmi & Kaipia, 2022)
Development of sensing, seizing, and transformation capabilities; capability development	(Karaosman et al., 2017; Salmi & Kaipia, 2022)
Sustainable leadership; management commitment	(Nguyen et al., 2020; Pedersen & Andersen, 2015)
Adapt new standards and rules; product certification and process certification	(Karaosman et al., 2017; Moretto et al., 2018; Nguyen et al., 2020)
Formulation of self-controlling and soft regulating instruments (ethical norms, social responsibility awareness, trust-building); creating fundamentals for business culture and promoting common values system; integrating sustainability in the company culture	(Claxton & Kent, 2020; Diabat et al., 2014; Moretto et al., 2018; Nguyen et al., 2020)