CRAFTING CONSCIOUSNESS -THE EVOLUTION OF FASHION INDUSTRY'S FROM INDUSTRY 1.0 TO 5.0: MASS PRODUCTION TO HYPER-CUSTOMISED AND SUSTAINABLE PRODUCTION

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ABSTRACT

As the global fashion industry journeys through the corridors of time, this research article navigates the transformative path from the era of Industry 1.0 to the technological frontier of Industry 4.0 and its extension as Industry 5.0 with interaction of human and machine. This illuminates the metamorphosis of fashion production from mass manufacturing to hyper customization coupled with embracing the sustainable alternatives. Situated within the thematic context of "Fashion Towards Post-Humanism" and the sub-theme "Beyond Growth to Introspection," this article embarks on a multidimensional exploration of a paradigm shift that resonates with the conscientious evolution of fashion.

Industry 1.0 marked the inception of mechanisation, setting the stage for mass production and widespread access to fashionable garments. A hallmark of this era was the proliferation of clothing, yet it also ushered in an age of environmental degradation and exploitative labour practices. As we transitioned through subsequent industrial epochs, the allure of growth dominated fashion's narrative, overshadowing ethical considerations and environmental concerns. However, the advent of Industry 4.0 heralds a momentous transformation. This era, defined by automation, artificial intelligence, and interconnectivity, is catalysing a profound shift within the fashion industry. Technological advancements, once associated with mass production, now serve as a bridge to sustainable alternatives. Sustainability, ethical production, and mindful consumption are at the forefront of this industry evolution. Whereas industry 5.0 embarks on a post- pandemic narrative bringing human and environmental elements back into equation with robotics and smart machines. It can be termed as the continuation of the 4.0 Industrial revolution.

The research article delves into various facets of fashion's evolutionary journey such as; (1) Technological Revolution exploring the pivotal role of Industry 4.0 technology such as Internet of Things (IOT), artificial Intelligence (AI), block chain, in enhancing supply chain transparency, minimising waste, and optimising production processes. (2) Sustainable Practices: Our study explores the adoption of sustainable materials, circular fashion concepts, and innovative production techniques that mitigate the environmental footprint of fashion production. (3) Conscious Consumerism: Analysing the emergence of conscious consumers, examining how digital platforms empower individuals to make

informed and ethical fashion choices, thereby driving industry practices towards greater sustainability. (4) Post-Humanism and Fashion: This article considers the intriguing intersection of post-humanism and fashion, shedding light on how technology is reshaping our relationship with clothing and self-expression and emerging technologies like 3D printing, virtual fashion, and bio fabrication. (5) Future Prospects:Paper speculate on the horizon beyond Industry 4.0, envisioning the transformative potential and human machine symbiosis. Highlighting technologies like smart factories with the highest level of perfection and added sustainable human centric concepts to the 5.0 industrial revolution. The key trends of Fashion industry 5.0 were identified & analysed using a mixed research approach, where quantitative analysis included a systematic literature review using the PRISMA framework and qualitative content analysis was conducted to understand the use of digital technology in design, production, and consumption resulting in a more environmentally aware and accountable approach within the fashion supply chain. This article contributes to a nuanced understanding of the fashion industry's ongoing metamorphosis and its convergence with the values of introspection, ethics, and sustainability. This inquiry serves as a catalyst for meaningful dialogue and action, forging a path towards a post-humanist and introspective era in fashion, where growth is not an end in itself but a means to a more sustainable and ethical future.

1. INTRODUCTION

The fashion industry has undergone a substantial metamorphosis, transitioning from its conventional, labour-intensive, and skill-centric origins characterised by limited production capacity to the era of mass production, advancing from Industry 1.0 to Industry 3.0. Renowned for its creativity and innovation, the industry has gained recognition for its negative social and environmental impacts, particularly concerning global climate change, population growth, and resource competition. As this transformation progresses into Industry 4.0, there is a pronounced emphasis on sustainability and conscious production practices.

In response to these concerns, the fashion industry is adjusting to accommodate a conscientious customer base and adopting sustainable practices. The COVID-19 pandemic has expedited the process of digitalization, giving prominence to immersive technologies such as AR/VR. This transformation aims to prioritise environmental preservation, human welfare, and long-term financial sustainability, optimising design, manufacturing, and business processes for tangible goods (Zou, Luh, and Lu, 2022).

The research delves into the impact of digital technologies propelled by the "Fourth Industrial Revolution," a paradigm shift reshaping major industrial systems. Despite well-established frameworks for the 4.0 paradigm, there is a noticeable lack of research on specific implementation strategies and their effects on various systems. The paper critically examines the current state and trends of digitization that are transforming the fashion industry.

Successful digital transformation holds the potential to reconfigure the fashion industry towards an eco-friendly and customer-centric model. Nonetheless, traditional brands encounter challenges in assimilating these changes. The study endeavours to unveil potential pathways for integrating the textile and clothing industry with Industrial Revolution 5.0 by scrutinising current events that have not been comprehensively explored.

1.1 Aims of the study

The research paper explores the complex journey, analysing a significant change in fashion practices as a result of industrial revolution 4.0 and 5.0 that reflects the digital transformation at various stages of supply chain and multi-dimensional perspective of sustainability.

- The study aims to map the key trends transitioning from industry 4.0 to 5.0 which will result in seamless integration of digital technologies relevant for the Fashion Industry through systematic literature review (SLR).

- The study examines the relationship between Industry 5.0's keyword trends and clusters with focus on circularity and sustainability concerns through bibliometric analysis and network visualisation mapping to explore new devel-

opment and emerging trends.

- It further investigates these trends and clarifies how the integration of digital technology and human machine symbiosis is contributing to the fashion industry's overall objective of sustainability.

1.2 Literature Review

1.2.1 History of Fashion Production-

The history of fashion production is a journey that reflects the evolution of manufacturing methods, in response to shifting economic, technological, and environmental circumstances. It is the most crucial sector in economic history. Recently, there has been a renewed focus on clothing manufacturing due to its heightened social and environmental impact. Therefore, it is worthwhile to examine the existing documentation regarding the evolution of the clothing industry. Conventional historiography can be categorised into four distinct groups. Prior to the Industrial Revolution, fashion production was distinguished by the use of highly skilled labour and meticulous craftsmanship, as artisans painstakingly crafted garments by hand. This period prioritised excellence over abundance, with each item serving as a testament to the expertise and creativity of the artisans. Subsequent to the industrial revolution, there have been three eras characterised by notable technological advancements and shifts in manufacturing paradigms.

1.2.2 Journey of Industrial Revolution witnessed by Fashion Industry-

Industry 1.0, which occurred from the late 18th to early 19th century, was characterised by the implementation of steam power, leading to a significant transformation in textile manufacturing. The advent of water and steam-powered machinery resulted in the substitution of manual labour, thereby resulting in a significant boost in productivity. During the period known as Industry 2.0, which occurred from the late 19th to the early 20th century, the utilisation of electricity became more prevalent, leading to a significant enhancement in manufacturing productivity. Henry Ford's assembly line concept emerged, allowing for mass production of standardised goods. Specialisation and division of labour emerged as crucial characteristics, enhancing the pace of production.

Industry 3.0, which emerged in the mid-20th century, with the inventions of transistors and microprocessors, which prepared the way for automated production, which was backed by numerous electronic equipment, Digital sensors and computers. It transformed the fashion industry by incorporating electronics and information technology into its structure. It enabled the expansion of global trade. It enabled the capacity to customise products on a larger magnitude, offering a greater array of personalised choices. (Figure 1).

1.2.3 Impact of Digitization and Fashion evolution-

Industry 4.0, which emerged in the late 20th century and continues to the present, has had a significant impact on the fashion industry. Through the integration of digital technologies like IoT, AI, and Big Data into production processes, lead to smart manufacturing. Several studies (Kalbaska, Sadaba, &Cantoni, 2018; Nobile &Kalbaska, 2020; Noris, SanMiguel, &Cantoni, 2020; Permatasari&Cantoni, 2019; Wang & Ha-Brookshire, 2018 as cited in Nobile, Noris, Kalbaska, &Cantoni, 2021) have explored this phenomenon. Machines and systems engage in real-time communication, enhancing efficiency, generating virtual replicas of physical systems for simulation and analysis, reducing errors and downtime, and enabling rapid prototyping and customization. This technological transition is in line with sustainable practices, as it enables accurate inventory management, decreases overproduction, and minimises resource wastage.

Industry 5.0, an emerging trend, focuses on collaboration between human workers and intelligent machines, emphasising personalised and environmentally sustainable production. The objective of Industry 5.0 is to create highly customised products and flexible production systems that rapidly adapt to changes and disruptions. This trend signifies a shift towards more environmentally conscious and technologically advanced approaches in fashion production.

The convergence of circular economy principles, Industry 4.0 technologies, and Industry 5.0 principles underscores the importance of human creativity, sustainability, and adaptability. The overarching objective is to reduce the environmental footprint of the fashion industry while leveraging innovation to create a more conscientious and streamlined apparel manufacturing sector.

Industry 1.0 (1800)	Industry 2.0 (1900)	Industry 3.0 (2000)	Industry 4.0 (2010)	Industry 5.0 (2020)
-Mechanisation -Water & Steam Power - 1st Mechanical Loom	-Mass Production, -Electric power, -1stAssembly Line	-Computers, Automated production, -IT Systems, -Electronics -Digital Sensors and computers at Shop Floor	-IOT -RFID -Robotics & AI -Big Data -Cloud Computing, -Cyber-Physical Systems - Smart Manufacturing - Sustainability -Rapid prototyping	-Hyper-Personalization OR Mass Customization - Digital Twins -Metaverse -Sustainability -Society 5.0 -Human centricity -Human-Robotics (co - working) -Bio- economy

Fig. 1. Evolution of Industry 1.0 to 5.0 witnessed by Fashion Industry. Adapted from figure, From Industry 1.0 to 5.0, "Industry 5.0 and Human-Robot Co-working" by author Kadir Alpaslan Demir et al, 2019 (source: https://doi.org/10.1016/j.procs.2019.09.104)

2. MATERIALS AND METHODS

The rapid advancement of industrial paradigms as a result of technological leaps and the significant socioeconomic impacts, it is critical to analyse the literature status quo and project the future landscape of Fashion Industry 5.0. The analysis employed a mix method technique and was divided into two sections, where in the first section a systematic literature review (SLR) was conducted using the PRISMA framework for data collection through various sources. Two major keywords searches were developed on Web of science and Google scholar i.e "Fashion Industry 4.0 Or Industry 4.0" and "Fashion Industry 5.0 Or Industry 5.0", were broadly used to describe technological advancement in the industrial production process. The initial search results revealed 204 documents in Google scholar, and 69 WOS (Web of Science) articles for the evaluation purposes. The inclusion and exclusion criteria were set as research articles of journals published during 2018-2023 by the reputed publishers (such as Elsevier, IEEE, MDPI, Springer, Wiley Online Library, Taylor & Francis, Sage Publication etc.) were considered for analysis. An SLR can benefit from both qualitative and quantitative methods by using meta-analysis, which occurs prior to the qualitative evaluation of the selected articles and thus mitigates the impact of selection bias in a narrative literature review. The reviewed data set was analysed using Bibliometric method tool VOS viewer to identify the co-occurrence of key trends in Industry 5.0.
In the next section the qualitative content analysis was conducted to understand the impact of identified key trends which are shaping the trajectory of Fashion Industry and predicting the future.

3. RESULTS

3.1 Systematic Literature Review

The literature was sought and analysed using 02 meta-databases: Web of science (WOS) and Google Scholar. These two databases were used due to comprehensive coverage of quality indexed journals and credibility and availability. The PRISMA framework / flowchart was used for screening the data. The search string was created by combining the operator 'OR' in between each two of the following terms: 'Fashion Industry 5.0', 'Digital Transformation,' 'Digitization, 'Sustainability', 'Fifth Industrial Revolution,' and 'Industry 5.0' (Table 1).

Database	Topics	Keywords	Results
Web of Science	Fashion Industry 5.0	"Fashion" OR "Industry 5.0" AND "Industry 4.0" OR "Digital Fashion" OR "Digitization" OR "Technological Advancement"	19
	Industry 5.0 and Sustainability	"Sustainability" OR "Supply chain" OR "Circular Economy" OR "Circularity in Fashion" AND "Industry 5.0"	50
Google Scholar	Industry 4.0 and Industry 5.0	"Fashion Industry" OR "Industry 4.0" AND "Industry 5.0" OR "Sustainability"	204

Table 1. Literature searching strategies

The Title- Abstracts & Keywords of 273 publications were screened using Zotero as a tool. The papers were filtered on the basis of their relevance to Fashion Industry, Industry 4.0, Industry 5.0, Digitization in Fashion Industry and sustainability. Finally, 129 papers were selected for further bibliometric analysis (Figure 2). The RIS file was extracted from Zotero for bibliometric research.

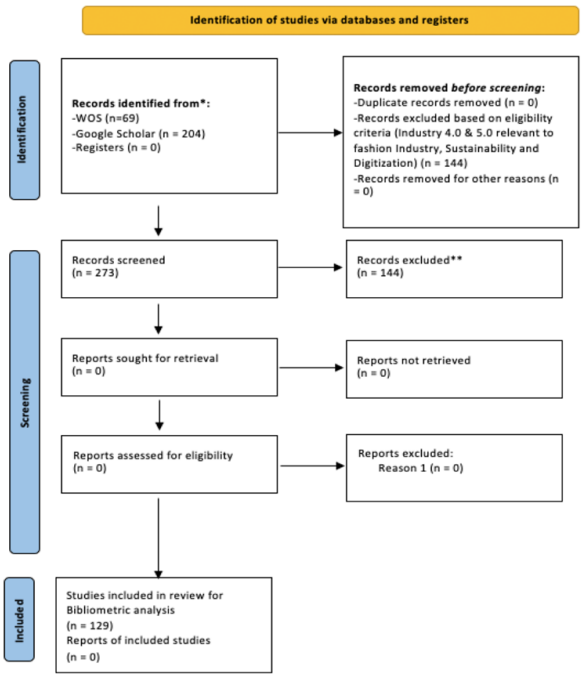

Fig. 2. Industry 4.0 & 5.0 Key trends for future of Fashion Industry: Analysis using PRISMA 2020 Framework for Systematic Literature Review

3.2 Bibliometric Analysis

A bibliometric analysis is a quantitative evaluation of collected research articles that allows scholars to statistically study the available bibliometric data from various perspectives (Okoli, & Schabram, 2010). This paper focused on identifying the key trends or keywords for Industry 5.0. To further analyse the blueprint for progression of Fashion industry in near future. Thus, for this a co-occurrence analysis of keywords was conducted using VOS viewer to generate a network map. Keyword co-occurrence analysis computes the number of times each keyword is used as well as the interaction between pairs of keywords. This investigation is depicted in figure 3. Where the keywords are represented by nodes whose size is proportional to the number of occurrences of the respective keyword. The links represent the interaction between keywords, and their thickness indicates the frequency with which each pair of keywords is used together. To generate sufficient and consistent results, 'all keywords' is considered for network generation, which includes indexed keywords as well. Last but not least, the minimum number of occurrences required to generate the visualization is set to 5, yielding 27 results (Figure 3).

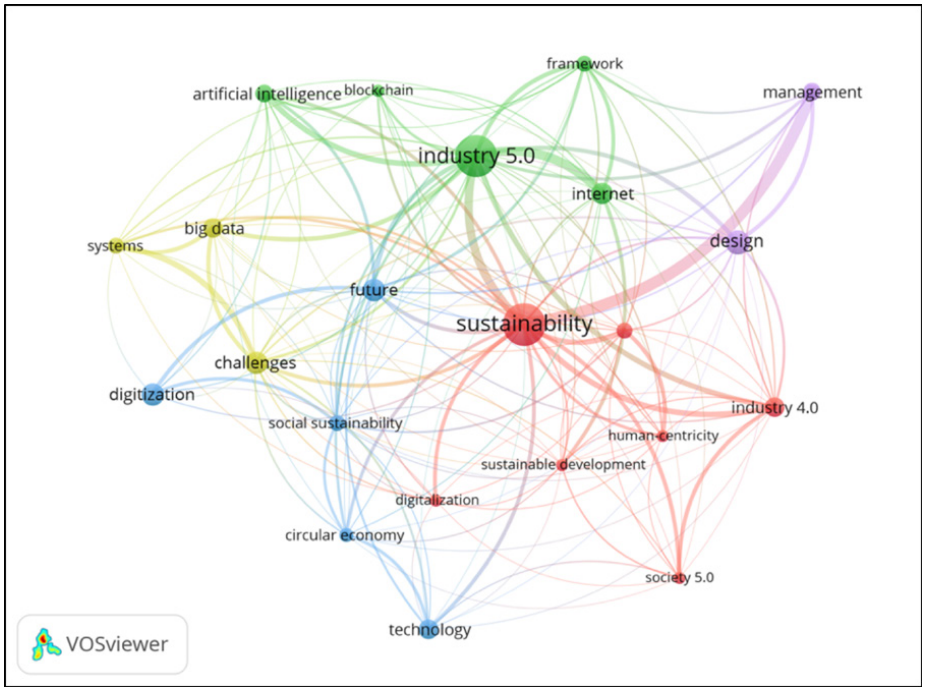

Fig.3. Keyword Co-Occurrence Analysis of Industry 5.0 And Sustainability.

The most influential strong connection can be seen between Industry 5.0 and Sustainability. Cluster 2 signifies strong connection between Industry 5.0 with IOT, Artificial Intelligence and Block chain. Similarly cluster 3 addresses the focus of Sustainability which was prevalent in Industry 4.0 as well and is continuing with human centricity and society 5.0 as new trajectories. Cluster 4 highlights the challenges we might continue to face such as Systems, big data etc. The data obtained from google scholar was also analysed after reviewing the titles, abstracts and keywords. From which few more keywords were derived in relevance to Sustainability or Circularity in fashion with digitization where keywords such as Cobotics, AI, Virtual Prototyping, 3D printing, Hyper personalization, Virtual Simulations, DHM (Digital Human modelling), e- libraries and Digital twins etc. were also mapped (Figure 4).

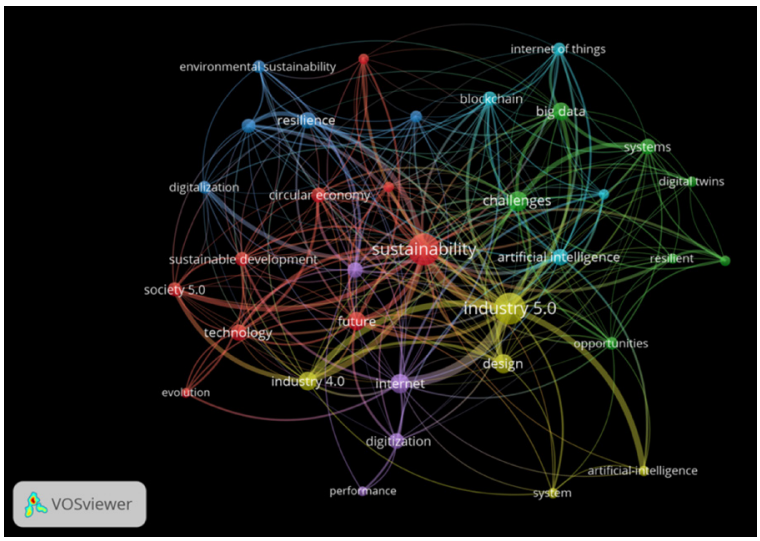

Fig. 4. Co-occurrence Network mapping for Digitization in Fashion Industry.

3.3. Content Analysis and Discussion

The results of bibliometric analysis of keywords revealed that there is an increasing trend of Societal, human-centricity and sustainability which are key elements of Industry 5.0. The evaluation of most extensively used keywords emphasised on adoption of new technologies keeping in mind sustainable aspects and bringing back human context into the picture by collaboration of robotics and human, man and machine, smart societies, resiliency, bio economy etc.

The technological revolution of Industry 4.0 was pivotal for development of Industry 5.0, it is also assumed that Industry 5.0 is an extension of Industry 4.0. Hence it is important to understand the technological development and its contribution in the Fashion Industry by content analysis (Table no.2). The content analysis is divided into following segments:

Technological Revolution (Industry 4.0)	**Sustainable practices**	**Conscious Consumerism**	**Post Humanism in Fashion**	**Industry 5.0**
-IOT enabled RFID -AI - Block chain -3D Printed components	-Resiliency -Human Interaction - Circularity	- Social, sustainable and ethical practices -Transparency in Supply chain -Minimal or Anti-consumerism -Virtual try-ons	-Cyber physical societies -Techno-logical Post-humanism -Human –robot interaction	-Human centric approach - Metaverse -Virtual Prototyping - Smart Societies and Society 5.0 - Bio economy -Cobots -Hyper Personalisation -Digital Twins & E-libraries

Table 2. Bibliometric insights into existing trends Industry 4.0 and emerging trends of Industry 5.0

3.3.1 Technological Revolution Industry 4.0

3.3.1.1 IOT Enabled production lines with RFID tagging

The fashion industry is leveraging the Big Data Era to analyze various types of data, including point-of-sale (POS) data, geographic information systems (GIS) data, social media, sensory, and physical data. An IoT-enabled production line with RFID tagging refers to the integration of Internet of Things (IoT) technology and Radio-Frequency Identification (RFID) systems in the Apparel manufacturing process. IOT enables Real-Time Visibility, Enhanced efficiency, Rapid and Precise Traceability, Data-Driven Decision Making, Enhanced Inventory Management, Energy and Resource Efficiency, Enhancing Equipment Longevity through Preventive Maintenance etc. This technology's ability to provide real-time visibility, make data-driven decisions, and implement sustainable practices makes it a catalyst for promoting positive environmental and operational changes in the apparel industry.

3.3.1.2 Artificial Intelligence

Artificial intelligence (AI) is based on the idea that human intelligence can be described in such a way that it can be replicated by a computer capable of performing tasks of any complexity level (Frankenfield, 2022). AI programming focuses on three cognitive abilities: learning, reasoning, and self-correction. (Burns, 2022). The fashion industry is undergoing a massive paradigm shift from an experience-based business model to a highly data-driven business model, with AI contributing to accelerating the entire process, having an impact in areas such as trend analysis, fashion recommendation, supply chain management, sales forecasting, and digitized shopping, among others. (Wazarkaretal. 2020). Zou and Wong (2021) have summarize the studies conducted over several decades into consolidated research by categorizing the use of AI in Fashion into seven groups: Overview, Evaluation, Basic Tech, Selling, Styling, Design, and Buying. Bolesnikov et al 2022 through their findings interpreted that participants are willing to change their purchasing decisions to more sustainable choices if provided with information by AI about the ecological risks. AI can optimize the fashion supply chain by improving efficiency and reducing waste. It can assist designers by providing insights into sustainable fashion choices in terms of material, design, patterns, production methods and in turn promote hyper personalized fashion recommendations. AI-driven tracking systems facilitate return, recycle, and repurposing, optimizing energy consumption in manufacturing facilities and can leverage implementation of circular economy practices.

3.3.1.3 Block chain for Supply chain authentication

Block chain technology is a growing list of blocks, enhancing digital transaction security and anonymity through cryptography algorithms. Where "Mining" is the process of creating, or digitally generating, new cryptocurrency coins. (Angelopoulos and Panopoulos, 2023). It improves supply chain visibility, real-time data sharing, and integration of processes. Block chain technology also provides design-related documents for sharing and can create trust in the supply chain process through smart contracts (Kamble, et al., 2019). Its security, traceability, efficiency, and transparency make it a valuable tool for supply chain management, because there is no way to change the record on the block chain, the transactions and decisions of supply chain members are properly recorded and documented on the block chain technology.

3.3.2 Sustainable Practices

Sustainability, resilience and human interaction- For the past five years, there has been an increasing debate about the continuation of the Industry 4.0 idea and attempts to combine additional areas beyond technologies with the cipher "5.0." These include efforts to reintegrate people into industry, an emphasis on resource efficiency and consequently sustainability, and efforts to incorporate circular economy principles to minimize the environmental impact at apparel product life cycle. The European Commission's explicit demand to create a legal framework for innovation, research, and industrial policy as a "Green Deal", "Industry 5.0", or "Green Industry" (European Commission 2021 and 2022). According to Banholzer (2021b and 2022a), society and hence politics are going through a paradigm shift, which is significant when contemplating the crisis phenomena caused by pandemics. A Circular Economy is a mode of production and consumption that emphasizes the sharing, renting, reusing, repairing, and recycling of existing materials and products. Digitalization has the potential to be extremely beneficial in the development of products within a circular economy (Agarwal et al., 2021).

3.3.3 Conscious Consumerism

Conscious consumerism is a movement and thought process that encourages individuals to make mindful purchasing decisions based on ethical, social and environmental considerations. The principles of conscious consumerism involve sustainability, ethical labour practices, social responsibility, minimalism and Anti- consumerism, supporting local and small businesses, educating consumers about the impact of their choices. While industry is undergoing transformative changes conscious consumerism can intersects with Industry 4.0 and 5.0 trends such as automation and sustainable practices, supply chain transparency using block chain, reducing waste through customization and personalization, achieving circular fashion economy by managing product lifecycle, virtual try-ons and augmented reality, localized production centres by reducing carbon footprint, empowering consumers by providing them more information by enabling technology.

3.3.4 Post-Humanism and Fashion

The term post-human refers to what human is or rather becomes “before, beyond, or after the human” (Bruce and Manuela, 2017). “When humans (or social robots or artificial intelligence) are functionally integrated into a cyber-physical system (CPS) at the social, cognitive, and physical levels, the system is referred to as a “cyber-physical-social system” (CPSS)”. A post humanistic aesthetics in relation to fashion could be dramatic and bizarre eg. Cyborg which is a hybrid of human and machine or digital material. Many designers and brands are experimenting on similar concepts. Where technology is integrated in the age-old techniques of production such as spinning, weaving to the factories in an industrial set up for cut, make and trim (CMT) to 3D CAD, wearables to virtual fitting rooms which are reality in the current times (Anneke, 2021). It can include material innovation such as bio fabrication, smart textiles, adaptive clothing, 3D printed custom components to ensure a quick response to consumer demand. The integration of advanced technologies enhances the fashion experience, promotes sustainability, and challenges traditional notions of what clothing and fashion mean in a rapidly evolving, post-humanistic era.

3.3.5 Future Prospects for Industry 5.0

The apparel industry’s future prospects transcend the existing Industry 4.0 framework, ushering in a new era characterised by Industry 5.0. Industry 5.0 is termed as the revolution in which man and machines are finding new ways to work together to make manufacturing more efficient and effective (Imoize et al. 2021). The anticipated transformation is defined by the smooth incorporation of cutting-edge technologies, intelligent factories with unparalleled accuracy, and a balanced relationship between humans and machines. In this analysis, we explore the fundamental elements or keywords that were derived from co-occurrence bibliometric analysis. These elements are shaping the future of the apparel industry, emphasising the merging of advanced technologies and environmentally conscious, people-centred ideas which are proposed in Industry 5.0.

3.3.5.1 Human centric approach:

Human interests are the primary focus of production, and technology enables industry workers to aid and advance their skills and knowledge (Yao et al. 2017). The concept of human centricity in artificial/digital systems is also known as ‘human in the loop,’ which refers to situations in which people are actively involved in decision-making activities or physical actions within an otherwise automated process flow. Human in the loop is important in the Industry 5.0 agenda and has been studied by a number of authors in terms of its application in manufacturing. A human-centric approach in the fashion industry also places a strong emphasis on the well-being, needs, and preferences of individuals throughout the entire lifecycle of a product. It involves considering the social, cultural, and ethical (fair wages and working conditions), individual experience through personalization as a dimension of fashion, with a focus on creating positive experiences for both consumers and the workers involved in the production process.

3.3.5.2 Resilient

The adjective “resilient” is becoming more popular. It is thought to be useful to describe the characteristics of the

Industry 5.0 concept, particularly in the effects of the COVID19 pandemic on economies, societies, and industries. Social and environmental needs are driving the development of the new concept. Sustainability emphasises that profit-driven businesses are increasingly difficult to sustain in a globalised and highly volatile (unpredictable) environment. The essence of Industry 5.0 is the symbiosis of three segments: technological, social, and ecological.

3.3.5.3 Metaverse

Neal Stepheson coined “Metaverse” in his science- fiction novel Snow Crash in 1992. Tlili et.al (2022) mentioned that the Metaverse is ‘the combination of the prefix “meta” which implies transcending or beyond with the word verse derived from “universe” which describes a parallel or virtual environment linked to the physical world’. The intersection of Metaverse and the fashion industry provides innovative opportunities for digital fashion experiences, virtual commerce, and new modes of self-expression. There are several ways Metaverse can be explored for achieving sustainable goals in Industry 5.0 through Virtual fashion shows, digital fashion items, Augmented Reality Try-ons, Virtual retail spaces, Digital avatars or identities, fashion collaborations in the virtual world, digital fashion platforms, customizations and personalization to name a few. As Metaverse continues to evolve, the relationship between digital spaces and the fashion industry will likely become more and more dynamic.

3.3.5.4 Smart Societies and Society 5.0

Over the last decade, there has been an exponential technological advance, laying the groundwork for an entirely new level of automation and the realisation of Society 5.0. The “Society 5.0” ecosystem will promote economic, environmental, social, and political sustainability while emphasising people and the creation of added value. Society 5.0 is, by definition, a technologically driven evolution of Industry 4.0 and the generalisation of the upcoming Industry 5.0. Three critical areas are specifically targeted: human centricity, resilience, and system and network sustainability. The ultimate goal is to build what has been envisioned as a super-smart and intelligent society.

3.3.5.5 Bioeconomy

The circular bioeconomy focuses on sustainable biomass utilisation in integrated production chains, optimising biomass value over time (Stegmann et al., 2020). Fashion brands are promoting sustainability and circularity by using recycled and bio-based textiles. The fashion industry faces challenges like short product life cycles, high product variety, and unpredictable demand (Sen, 2008). A sustainable approach requires the “take, make, waste” principle throughout supply chains (Brydges, 2021). Initiatives to reduce CO2 emissions, water, and energy consumption are underway (Grazzini et al., 2021). Use of bio based products and achieving circularity in product life cycle, re-using and recycling clothing. Currently, natural fibres derived from biomass are used in 29% (weight perspective) of the apparel and textile industries, including cotton, linen, flax, cellulose, coir, bamboo, jute, banana, wool, natural leather, natural silk, natural fur and hair, and so on (Ütebay et al., 2020). There is a rising trend of using innovative bio-fibres such as seaweed fibre, milk fibre, alge fibre, lotus fibre etc. but it is limited in quantity and expensive. Hence the bio economy has a huge potential and can provide a roadmap for future circularity in fashion.

3.3.5.6 Cobots or Human robotics co- working

The excellent quality of manufactured products can be achieved through integration of automation and robotics, but for customization human being is the key element. Hence the concept of cobotics was brought as a solution to human and robotics collaboration. Where robots are designed to work in sync with the human employees. As per the Deloitte (2018) article on ‘The skill gap in US manufacturing 2015-2025 outlook’ where it stressed upon putting human back in the loop by expanding digital and soft skills and leveraging digital tool box. In industry 5.0 the collaboration between Cobots and humans will result in increased productivity, quality, output level and innovation. Where robots will take up the strenuous, mundane and dangerous jobs while humans can focus on more satisfying higher job positions. Cobotics can facilitate human-robot collaboration in design, allowing designers to prototype, iterate, and optimise designs. Cobotic systems excel in precision tasks like cutting and sewing, ensuring high quality while maintaining flexibility. They can also be used in tailoring and customization, providing personalised products. They

can collect real-time data and analytics, facilitate rapid prototyping and iterations, enhance worker safety, assist in logistics and material handling, and provide interactive assistance in retail settings. This collaboration enables the fashion industry to meet customization, sustainability, and rapid innovation demands.

3.3.5.7 Hyper Personalization

In the past few decades there is a paradigm shift in the manufacturing processes from Mass production to Mass customization in Industry 4.0 to Personalization in Industry 5.0. With the proper balance of automation and human touch, Industry 5.0 enables customers to receive the exact product and services that match their particular needs. The current industrial revolution's deployment of artificial intelligence, 3D printing, virtual reality, and adaptive manufacturing fulfils the concept of product and service personalization based on customer or business requirements by enabling the industry to follow a proper manufacturing process. The improved manufacturing capabilities and allow for more individualised and customised products or services, which is founded on the concept of "design freedom." Hyper customisation is a personalised marketing strategy that uses cutting-edge technology such as AI, machine learning, cognitive systems, and computer vision on real-time data to give more particular product, service, and content to each customer. Industry 4.0 intended for mass manufacturing with minimal waste and maximum efficiency, whereas Industry 5.0 aimed for mass customisation at the lowest possible cost and with the greatest possible precision. The transformation to an agile manufacturing process and supply chain is the first stage toward hyper-personalization.

3.3.5.8 Digital twins & E- library

The incorporation of digital twins into the garment industry 5.0 represents a significant change in how clothing is designed, manufactured, and delivered. Digital twins, that are virtual replicas of physical garments and their associated processes, provide a dynamic and all-encompassing approach to industry innovation. It can create an exact copy of the physical operation in real- time hence reducing the fabric wastage and increasing efficiency. Digital twins can be effectively utilised in apparel manufacturing for product development and production processes, allowing virtual simulations to identify production problems, wastage, and efficiency issues. The use of e-library resources elevates the garment design process to a data-driven and customer-centric level. Manufacturers can access a wealth of information about body size diversity, fashion trends, and customer preferences via e-libraries.

4. CONCLUSION

The paper introspects the post humanistic and introspective era of fashion, highlighting the evolving relationship between technology, humanity, and the fashion industry. The evolution of the fashion industry from Industry 1.0 to 5.0 reflects significant changes in technology, consumer behaviour, and business practices, with a growing emphasis on sustainability. The paper investigates the transition of industry 4.0 to industry 5.0 where the I5.0 is considered to be the extension of I4.0. While there have been various studies on Industry 4.0 but there is a dearth of research in the area of Industry 5.0 as it is at its nascent stage. Hence the current study aims at investigating the existing technological integrations and the emerging trends of Industry 5.0 which is shaping the future of the Fashion industry. The study employed the SLR method for analysing the existing literature related to technological advancement in the fashion industry in sync with sustainability goals. Where 129 papers were selected for further bibliometric analysis to study the co-occurrence of key trends which resulted in 27 key words. The Keyword co-occurrence analysis computed the number of times each keyword is used as well as the interaction between pairs of keywords. The results were obtained from network mapping of WOS meta-data and by investigating the abstracts extracted from various papers on google scholar. The meta-analysis highlighted sustainability, human centricity, social sustenance, circular economy, resiliency, society 5.0, digitization, AI, cobotics, hyper-personalization as emerging trends of Industry 5.0. With an increasing recognition of the need for responsible and ethical practices, sustainability has become a central focus in the modern fashion landscape.

The intersection of post-humanism and the fashion industry opens up exciting possibilities for the future of fashion.

The confluence of a post-humanistic era with Industry 4.0 or 5.0 creates a landscape where advanced technologies and redefined notions of humanity coalesce to shape the future of industry and society. It entails rethinking human identity, embracing technology as an enabler, and investigating novel ways to improve the fashion experience while addressing ethical and sustainability concerns. The combination of these ideas reflects a dynamic and changing landscape in which technology and humanity come together to shape the future of the fashion industry.

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