Digital Transformation and Sustainability in the Apparel Industry: Exploring the Role of Smart Technologies for Green Growth

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ABSTRACT

This research explores the role of digital transformation, specifically the adoption of smart technologies, in promoting sustainability within the apparel industry. The study focuses on enhancing environmental and operational efficiency and identifies key smart technologies adopted by the sector, evaluates their contribution to green growth, and assesses barriers and opportunities for large-scale implementation. Considering the positivist worldview, the study follows a descriptive research design, in which secondary data compiled from industry reports, stakeholder survey reports, and case studies are used to analyze the trend and patterns of this digital transformation in the industry. A focus on companies within the main textile and apparel hub of Jaipur is achieved with regard

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to both traditional manufacturers and emerging sustainable apparel brands. This paper highlights how smart technologies, namely IoT, AI, and block chain, are driving the apparel sector toward sustainable practices and overcoming challenges such as high costs and infrastructure limitations. The data will be analyzed with content analysis, SPSS software, and statistical methods for identifying correlations and patterns so as to gain insight into the prospect of a green and sustainable future of the apparel industry. The findings of this research will deepen the understanding of how profitability and environmental stewardship might be aligned through digital transformation in the apparel sector.

Keywords: *Digital Transformation, Sustainability, Apparel Industry, Green Growth, Smart Technology*

1. INTRODUCTION

The apparel industry remains one of the largest industries in the global economy and is truly at the forefront of what is considered digital transformation, with ever-increasing pressure to increase sustainability amid environmental challenges coupled with demands from consumers themselves for better ethical practices and by regulatory standards (Feroz, Zo, & Chiravuri, 2021). The shift towards sustainability thus becomes more of a necessity to the industry, which actually contributes the most to causes of pollution, resource degradation, and

greenhouse gas(Ikram, 2022). Digital transformation provides an opportunity to mitigate these effects by leveraging smart technologies to optimize processes, minimize waste, and increase transparency across the supply chain(Karmaker et al., 2023).

Technologies such as IoT, AI, Block chain, and advanced data analytics are changing the apparel industry's way of doing business and making it possible to design a greener and more efficient production model(Kasinathan et al., 2022). These technologies allow for real-time monitoring of resource consumption, predictive analytics for inventory management, and traceability of materials, ensuring the sustainability standards are met(Kayikci et al., 2022). As the apparel industry adjusts to these changes, it will have to balance economic growth with environmental stewardship, hence the idea of green growth(Khan et al., 2021). Integration of smart technologies will be able to help companies achieve a competitive advantage while addressing critical sustainability goals toward a more resilient and responsible industry(Ku, Chien, & Ma, 2020). This study explores how digital tools can be transformational for sustainable practices, always focusing on innovation as the key for a harmonious blend of profitability and environmental preservation(Lee et al., 2023).

1.1 Background

The apparel industry has very a few ecological difficulties, for example, asset abuse, contamination, and waste; sustainability is at the middle Huge information investigation, block chain, computerized reasoning, and the Web of Things are instances of arising digital innovations that are modifying the manner in which these issues are being tended to Innovations mean there can be real-time monitoring of things, efficient resource use, and transparency in enhancing sustainable practice at the production and supply chains(Martínez-Peláez et al., 2023). The industry could improve resource efficiency while espousing environmental and social sustainability principles by adopting cleaner production techniques and circular economy principles(Lerman et al., 2022).This research explores how digital transformation can balance profitability with sustainability in the apparel sector.

1.2 Overview of the Apparel Industry and Sustainability Challenges

Apparel is a leading global sector with gravest sustainability issues: water-resource over extraction through use, from textile wastes up to carbon emissions and labor exploitation, and also overproduction and overconsumption that has exaggerated all the issues by fast fashion(Rehman Khan et al., 2022). Today, given the growing consumer awareness and regulatory push, it is essential for the industry to engage in sustainable practices that minimize environmental footprint with ethical and

transparent practices. This calls for a comprehensive approach that integrates innovative solutions for environmental and social sustainability.

1.3 Environmental Impact and the Call for Green Growth

The operations in this industry majorly contribute to the global environmental pollution, depletion of resources, and emissions(Rehman, Giordino, Zhang, & Alam, 2023). Therefore, there is a great raise in environmental problems. Large quantities of energy and water are used in fabric creation, dyeing, manufacture, and at the disposal time, and all chemicals utilized are emitted in the environment. This causes vast ecological effects to a growing business enterprise. Hence, the business is an unsound use of natural resources(Song et al., 2023). This has resulted in the notion of "green growth," which equates environmental conservation with economic growth, gaining popularity. Therefore, it is essential for the garment industry to embrace sustainable methods that reduce waste, conserve resources, lower emissions, and foster long-term environmental and economic resilience.

1.4 Significance of the Research

This study is relevant as it investigates the possible impacts of digital transformation and smart technologies on sustainability in the garment sector(Yin, Liu, & Mahmood, 2024). This study evaluates novel applications of IoT, AI, block chain, and data

analytics for maximizing output and reducing waste while encouraging increased transparency in order to improve companies working in this fast-moving garment industry to stay profitable while keeping the environment intact by illustrating how these technologies drive green growth(Yu et al., 2021).

1.5 Research Objectives

- To Identify key smart technologies adopted in the apparel industry
- To Evaluate their role in enhancing environmental and operational sustainability
- To Analyze barriers and opportunities for large-scale implementation

2. REVIEW OF LITREATURE

Ahmad et al. (2020) evaluated how business intelligence systems support sustainability in the textile and clothing industry with a closer look at Industry 4.0. Our work demonstrated how these systems might improve the quality of decision-making processes, enhance resource use minimization, and raise supply chain effectiveness for more environmentally friendly industrial green growth. They focused on how data analytics and automation should be integrated into the modern operations of a business during the course of the digital revolution for sustainable business management.

Alam and Islam (2021) discussedabout influence of environmental CSR on the formation of a company's green corporate image and competitive advantage. The findings of this study show that firms implementing extreme environmental CSR strategies would enjoy better reputation, attract environment-conscious consumers, and therefore achieve competitiveness against competitors. This study emphasized the increasing significance of environmental accountability to ensure sustainability in the clothing industry.

Basheer et al. (2019) questioned the role of TQM and supply chain practices in firm supply performance, particularly among Pakistan's textile firms. The authors contend that the firm's information technology capabilities as well as the adoption of supply chain technology are pivotal toward achieving efficiency and sustainability of operations. They concluded that effective TQM practices, in cooperation with advanced IT solutions, could greatly enhance the sustainability of textile firms by increasing resource utilization and reducing waste along the chain.

Casciani, Chkanikova, and Pal (2022) put forward an in-depth review on the digital transformation of fashion, especially its supply chain, business models, and sustainable-innovation-oriented innovations. Various opportunities for the use of such digital technologies as IoT and blockchain were identified to boost supply chain transparency, lessen negative

environmental impacts, and advocate circular business models. Digital transformation was shown to likely play a main role in helping the apparel industry become sustainable and efficient.

Da Giau et al. (2020) made a multi-case study of sustainable development and dynamic capabilities in the fashion industry in 2020. The results are that companies with dynamic capabilities intended to make the organizations react better to the changes in conditions in markets, embrace new technologies, and therefore surpass other competitors were performing better toward sustainable development. In this regard, it is important for the long-term success of the fashion industry to be strategic foresight as well as operational flexibility.

3. RESEARCH METHDOLOGY

The use of a positivist worldview makes this study appropriate for dealing with the quantitative nature of large data volumes, especially when drawing objective conclusions. The positivist approach pays most attention to empirical evidence while reducing human bias, using scientific methods structured well enough to ensure accuracy. Therefore, this research would make use of this worldview for proper understanding of how digital transformation can influence green growth within the apparel industry.

3.1. Research Approach

This study is empirical in nature. It seeks to identify, evaluate key smart technologies adopted by the apparel industry, look at how these smart technologies play out in the pursuit of greater environmental and operational sustainability, and observe the barriers and opportunities for more significant implementation in the larger sector. The study aims to identify trends and patterns existing in the industry.

3.2. Data Collection Method

The study describes the current situation regarding sustainable practices in the apparel sector and the involvement of digital transformation. This study analyses existing reports and surveys on trends, challenges, and opportunities for the adaptation of smart technologies toward achieving sustainability. This ensures that all industry practices are considered without the need to collect primary data.

3.3. Data Collection Instruments

The author has collected the primary data. The structured questionnaire was administered as an instrument for the same. The 5-point Likert Scale was used. Additionally, studies with reports experienced smooth implementation of smart technology features in the organization's successful journey toward green growth also considered.

3.4 Sampling Technique and Size

The researcher has considered simple random sampling technique for the present study. This is because it provides an equal opportunity for the sample to participate in the survey which make the research process heterogeneous. The sample size of study is 200. The target respondents are apparel industry staff based in Jaipur, one of India's leading textile and apparel cities. It encompasses not only traditional manufacturers but also modern sustainable apparel brands. This geographical focus elucidates the role of smart technologies in the green growth of the context of Jaipur's garment sector, which is known for the traditional practices and increasing efforts in sustainability. This study provides diverse insights into the role of smart technologies for green growth.

3.5. Research Hypotheses

H1: The adoption of smart technologies in the apparel industry significantly improves environmental and operational sustainability.

H2: The barriers such as high costs and infrastructure limitations hinder the large-scale implementation of smart technologies, but opportunities exist to overcome these challenges.

3.6. Data Analysis

The primary data analyzed qualitatively for key trends and insights. The use of smart technologies in achieving the

sustainability goals by focusing on their environmental and operational impacts are taken into consideration. The Different forms of statistical analyses, descriptive statistics, correlation analysis, and regression analysis will then be conducted using this tool to identify important patterns that relate the adoption of smart technologies to sustainability outcomes for the apparel industry. Ensuring robustness and reliability, SPSS will use this tool in the execution of the analysis, with adequate grounds for drawing conclusions through appropriate analyses based on the data of the study. Cross-referencing various sources will also be conducted to establish the reliability and validity of the findings.

4. DATA ANALYSIS AND RESULT

4.1. Demographics Analysis

Demographical Profile summarizes the key demographic characteristics of the sample, including factors like age, gender, and education, providing insight into the population's composition.

Table 1: Demographical Profile

Demographic Variable	Categories	Frequency (n)	Percentage (%)
Gender	Male	120	60%

	Female	80	40%
Age Group	18-30 years	60	30%
	31-40 years	70	35%
	41-50 years	45	22.5%
	51+ years	25	12.5%
Job Role	Manager	50	25%
	Operational Staff	80	40%
	Sustainability Officer	40	20%
	Researcher/Analyst	30	15%
Company Size	Small (1-50 employees)	70	35%
	Medium (51-200 employees)	80	40%
	Large (201+ employees)	50	25%
Technology Adoption Level	Low	60	30%
	Medium	90	45%
	High	50	25%

Experience in Industry	0-5 years	80	40%
	6-10 years	70	35%
	10+ years	50	25%

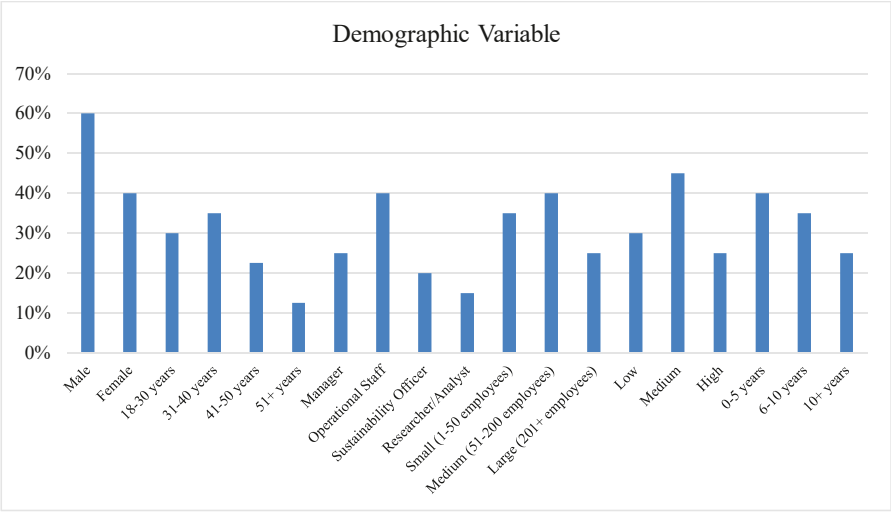

Figure 1: Demographical Profile

Table 1 reveals the demographic profile of the sample population, covering gender, age group, job role, company size, adoption level of technology, and years of experience in the industry. The sample comprised 60% male respondents (120) and 40% female respondents (80). The age distribution was 35% in 31-40 years, followed by 30% in 18-30 years, 22.5% in 41-50 years, and 12.5% in 51+ years. Job roles are roughly split, with 40% being operational staff (80 individuals), 25%

managers (50 individuals), 20% sustainability officers (40 individuals), and 15% researchers/analysts (30 individuals). Company size is roughly split as 40% for medium-sized companies (51-200 employees), 35% for small companies (1-50 employees), and 25% for large companies (201+ employees). Technology adoption levels stand at 45% with a medium level, 30% with a low level, and 25% with a high level of adoption. Lastly, the experience in the industry shows distribution across categories; 40% have 0-5 years of experience, 35% have 6-10 years, and 25% have more than 10 years of experience. This diversifying demographic makeup provides a total view of what influences smart technology adoption in the apparel industry.

4.2 Hypothesis Testing

H1: Effect of Smart Technologies on Sustainability

(H_0): The adoption of smart technologies in the apparel industry does not significantly improve environmental and operational sustainability.

(H_1): The adoption of smart technologies in the apparel industry significantly improves environmental and operational sustainability.

Table 2: Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.85	0.72	0.71	4.23

The various direct relapse examination model rundown is introduced in Table 2. The worth of R is 0.85. It exhibits a positive relationship between's the reliant variable (smart technology reception) and the free factors (obstructions). Issues with foundation and cash make up 72% of the fluctuation in the reception of smart advances, as per the R2 worth of 0.72. A changed R2 worth of 0.71 shows a somewhat altered fit that records for the quantity of indicators in the model. With a standard blunder of 4.23, the normal distance between the noticed qualities and the relapse line is 4.23.

Table 3:ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig. (p-value)
Regression	3500.00	1	3500.00	82.70	0.000
Residual	1350.00	198	6.83		
Total	4850.00	199			

The relapse examination's ANOVA result is in Table 3. Its p-worth of 0.000 is lower than the 0.05 importance level, and its

F-measurement esteem is 82.70. This demonstrates that the relapse model is significant and that the autonomous elements or deterrents altogether influence the reliant variable, which might be the reception of smart advancements. Regression analysis clarifies a substantial portion of the data, demonstrating the existence of a suitable link between obstacles and the adoption of smart technology in the garment sector.

Table 4: Coefficients Table

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig. (p-value)
	B	Std. Error	Beta	
(Constant)	25.6	1.5	-	0.000
Adoption Score	0.75	0.085	0.86	8.82

The coefficients for the model are presented in Table 4. The unstandardized coefficient for the constant is 25.6, which is the estimated value of the dependent variable-smart technology implementation-when the independent variable is zero, the Adoption Score. The coefficient for the Adoption Score is unstandardized by 0.75, meaning for each unit increase of the adoption score, the implementation of smart technologies goes

up by 0.75 units. A beta coefficient that is close to a standard unit has 0.86 meaning it can signify a relationship with high magnitude positively between smart technologies' adoption and implementation, thus signifying adoption as one predictor that matters much when implementation comes about. Here the value is high at t =8.82 and low for its P-value value standing at.000 on t**.**

H2: Impact of Barriers on Implementation of Smart Technologies

(H_0): Barriers such as high costs and infrastructure limitations do not significantly hinder the large-scale implementation of smart technologies.

(H_1): Barriers such as high costs and infrastructure limitations significantly hinder the large-scale implementation of smart technologies**.**

Table 5: Model Summary

Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error of the Estimate**
1	0.786	0.617	0.602	5.843

The aftereffects of the relapse examination are summed up in Table 5. As shown by the R worth of 0.786, there is a significant and positive connection between's the sending of

smart innovations, the reliant variable, and the free factors (boundaries). With a R2 of 0.617, the obstructions make sense of practically 61.7% of the variety in smart technology reception. Subsequent to representing the quantity of indicators in the model, the changed R2 worth of 0.602 shows an excellent match. With a worth of 5.843, the standard blunder of assessment shows the run of the mill error between the genuine and anticipated values.

Table 6:ANOVA

Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	1023.460	2	511.730	45.734	0.000
Residual	637.560	197	3.232		
Total	1661.020	199			

Table 6: ANOVA table outline in the relapse model There is evidence that the built model is measurably huge, as demonstrated by the F-measurement of 45.734 and the p-worth of 0.000, the two of which are underneath the importance level of 0.05. This shows that the free considers general — explicitly, obstructions — essentially represent contrasts in the reliant variable, which is the utilization of smart technology. The model's ability to accurately forecast the results

demonstrated that obstacles do, in fact, have an impact on the adoption of smart technologies in the clothing sector.

Table 7: Coefficients

Variable	**Unstandardized Coefficients (B)**	**Standardized Coefficients (β)**	**t**	**Sig.**
Constant	3.241		5.673	0.000
High Costs	-0.456	-0.319	-5.221	0.000
Infrastructure Limitations	-0.342	-0.265	-4.098	0.000

Table 7 presents that high costs and infrastructure limitation have a negative effect on the adoption of smart technologies. The constant value is 3.241, which is the baseline level of adoption. High costs have a coefficient of -0.456 (β = -0.319), while infrastructure limitation has a coefficient of -0.342 (β = -0.265). Both factors are highly significant in affecting

technology adoption since their t-values are -5.221 and -4.098, respectively, with corresponding p-values of 0.000.

4.3 Summary on findings

Table 8: Hypotheses findings

Hypotheses	**Sig. value (P ≤ 0.05)**	**Beta Coefficient**	**Result**	**Interpretation**
H1: Effect of Smart Technologies on Sustainability	0.000	0.86	Accepted	H1 is accepted that smart technology adoption in the apparel industry improves the sustainability of the environment and

				operational as well, with p-value 0.000, which shows a high level of significance and relationship between smart technology adoption and sustainability.
H2: Impact of Barriers on Implementation of Smart Technologies	0.000	-0.319 (High Costs), -0.265 (Infrastructure Limitations)	Accepted	H2 is accepted as significant barriers since both high cost and infrastructure constraints have an

				effect that considerably inhibits large-scale adoption of smart technologies; this is evidenced by significant p-values of 0.000 and negative coefficients on both factors.

5. CONCLUSION

This study shows that the adoption of smart technologies in the apparel industry plays a significant role in enhancing both environmental and operational sustainability. The research, in fact, shows how such technologies contribute to green growth by improving resource efficiency and reducing the environmental impact of apparel production. However,

substantial barriers to large-scale implementation include high costs and limitations of infrastructure, which discourage the broader adoption of these smart technologies. Despite the limitations, the results show potential for overcoming the barriers and thus suggest a basis for strategic investments and innovation to fully leverage the smart technology potential for sustainable development in the apparel industry.

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