

Exploring the Transition from Supply Chain 4.0 to Supply Chain 5.0 through Human-Centric Digital Transformation

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Abstract

Through the lens of human-centric digital transformation, this study investigates the shift from Supply Chain 4.0 to Supply Chain 5.0, emphasizing the roles of digital transformation technologies and human-centric practices in propelling this change as well as its implications for supply chain resilience and sustainability. A structured, five-point Likert-scale questionnaire covering Digital Transformation Technologies (DTT), Human-Centric Digital Transformation (HCDDT), Transition to Supply Chain 5.0 (SC5T), and Sustainability & Resilience (SSR) was used to gather data from 100 respondents mostly seasoned supply chain professionals using a quantitative, cross-sectional research design. Excellent internal consistency across all constructs was proven by reliability analysis (Cronbach's Alpha > 0.90). All four constructs had robust, statistically significant positive connections, according to descriptive and correlation analyzes. Both null hypotheses were rejected after multiple regression analysis revealed that DTT and HCDDT together explained 98.8% of the variance in the shift to Supply Chain 5.0. Both variables emerged as substantial positive predictors. The shift to Supply Chain 5.0 significantly predicts sustainability and resilience outcomes, according to an additional regression. These results imply that while digital technology continue to be the primary force behind supply chain transformation, human-centric integration plays a crucial complementary role and that companies adopting Supply Chain 5.0 see quantifiable increases in sustainability and resilience. In addition to providing useful advice for businesses, politicians, and researchers looking to negotiate a more balanced, human-centered digital transformation, the study adds empirical data to the growing Supply Chain 5.0 discourse.

Keywords: Supply Chain 5.0, Digital Transformation, Human-Centric Technology, Supply Chain Resilience, Sustainability

1. Introduction

Supply Chain 4.0, a technology-enabled paradigm focused on connectivity, automation, visibility, and data-driven decision-making, has emerged as a result of the quick spread of digital technologies, which has completely changed supply chain management. Organizations have been able to create more intelligent and responsive supply networks because to technologies like the Internet of Things (IoT), artificial intelligence (AI), big data analytics, blockchain, digital twins, and cyber-physical systems. These technologies improve supply chain visibility, operational efficiency, traceability, and real-time monitoring while bolstering businesses' capacity to adapt to market demands and disturbances. According to recent data, Industry 4.0 technologies are now intimately linked to better customer outcomes, traceability,

and supply chain efficiency.

But Supply Chain 4.0's growing technical intensity also poses a crucial query: does more digitalization always result in a more efficient and long-lasting supply chain? The skills, welfare, and decision-making function of those who run and oversee digitally integrated supply networks may be undervalued in a primarily technology-centric strategy. Supply Chain 5.0, which builds on the technological foundation of Supply Chain 4.0 by emphasizing human-technology collaboration, resilience, and sustainability, has emerged as a result of this issue. Therefore, Industry 5.0 builds on current digital capabilities while reorienting them toward human and societal goals rather than marking a total break from Industry 4.0.

In this regard, supply chains can move from technology-driven automation to technology-enabled human cooperation through the crucial process of human-centric digital transformation. However, current research on how this shift takes place and how well-established Supply Chain 4.0 technologies can be integrated with Supply Chain 5.0 concepts is still rather dispersed. Therefore, using the lens of human-centric digital transformation, this study investigates the shift from Supply Chain 4.0 to Supply Chain 5.0, looking at how digital technologies can strengthen human participation, resilience, and sustainability throughout supply chain ecosystems while also improving operational performance.

2. Literature Review

Zaoui et al. (2025) studied how supply chains have changed from an Industry 5.0 viewpoint, emphasizing resilience, sustainability, and human-centricity in the face of climate threats and disruptions. The authors concluded that digital technologies, especially AI, boost supply chain viability and decision-making after reviewing 71 peer-reviewed papers. Stronger theoretical and empirical research connecting human-centricity, sustainability, and supply chain resilience is necessary, as the human-centric factor is still understudied.

Samuels (2024) examined the shift from Industry 4.0 to Industry 5.0, focusing on sustainable supply chain management using human-centric technologies. The report highlighted the increasing importance of human interaction while identifying IoT, blockchain, big data, and AI as significant facilitators of supply chain efficiency, visibility, and resilience. It does not, however, provide a comprehensive framework that explains how the shift from Supply Chain 4.0 to Supply Chain 5.0 is driven by human-centric digital transformation.

Samuels (2024) examined the shift from Industry 4.0 to Industry 5.0 in sustainable supply chain management, emphasizing blockchain, big data, IoT, AI, and machine learning as important facilitators of efficiency, sustainability, and human-machine cooperation. The study also noted bionic supply chains as a new strategy that combines machine and human intelligence. The study, however, pays little attention to the precise processes that transform Supply Chain 4.0 into a human-centered Supply Chain 5.0.

Bashiri et al. (2023) conducted a thorough literature analysis to investigate the shift from technocentric Industry 4.0 to value-centric Industry 5.0. In addition to technology improvement, the study emphasized the increasing significance of human-centricity, sustainability, resilience, and stakeholder value. It does not, however, go into detail on how these ideas apply to the shift from Supply Chain 4.0 to Supply Chain 5.0.

Enang, Bashiri, and Jarvis (2023) used the Multi-Level Perspective (MLP) to perform a systematic literature review to investigate the shift from technocentric Industry 4.0 to value-centric Industry 5.0. According to the report, the main forces behind this shift include COVID-19, climate change, trust, mass personalization, autonomy, and rising technology. The study does, however, focus on the shift at the larger industrial level, offering little insight into how the shift from Supply Chain 4.0 to Supply Chain 5.0 is especially made easier by human-centric digital transformation.

3. Research Gap

The shift from Industry 4.0 to Industry 5.0 has been studied in the past, but the particular evolution of Supply Chain 4.0 into Supply Chain 5.0 has received less attention. Compared to features of technology and sustainability, the human-centric factor is still understudied. Additionally, there is no empirical data on how human-technology cooperation affects the performance, sustainability, and resilience of supply chains. Consequently, the shift to a human-centric Supply Chain 5.0 requires an integrated foundation.

4. Objectives

- To examine the role of digital transformation technologies in the transition from Supply Chain 4.0 to Supply Chain 5.0.
- To assess the influence of human-centric digital transformation on the transition from Supply Chain 4.0 to Supply Chain 5.0.
- To examine whether the transition towards Supply Chain 5.0 contributes to supply chain sustainability and resilience.

5. Hypotheses

- **H01:** Digital transformation technologies have no significant influence on the transition from Supply Chain 4.0 to Supply Chain 5.0.
- **H11:** Digital transformation technologies have a significant positive influence on the transition from Supply Chain 4.0 to Supply Chain 5.0.
- **H02:** Human-centric digital transformation has no significant influence on the transition from Supply Chain 4.0 to Supply Chain 5.0.
- **H12:** Human-centric digital transformation has a significant positive influence on the transition from Supply Chain 4.0 to Supply Chain 5.0.

6. Research Methodology

1. Research Design

In order to characterize respondents' perceptions and investigate the impact of digital transformation and human-centric digital transformation on the shift from Supply Chain 4.0 to Supply Chain 5.0, the study uses a descriptive and causal research approach.

2. Population of the Study

Students studying supply chain and logistics as well as professionals employed in supply chain, logistics, operations, procurement, and related sectors make up the population.

3. Sampling Unit

The sampling unit consists of a single professional or student with experience to digital technology and supply chain management in both academic and real-world settings.

4. Sample Size

Professionals and students studying supply chains will make up the study's sample of 100 respondents.

5. Sampling Technique

Purposive sampling will be used in the study, and participants will be chosen according to their professional or academic experience with supply chain management and digital

transformation.

6. Source of Data

The major data used in the study will be gathered via a standardized questionnaire. Research articles, journals, publications, and pertinent scholarly literature will be the sources of secondary data.

7. Research Instrument

The research tool will be a structured questionnaire. A five-point Likert scale, with 1 denoting "strongly disagree" and 5 denoting "strongly agree," will be used to rate each item.

8. Variables of the Study

Variable	Role
Digital Transformation Technologies	Independent Variable
Human-Centric Digital Transformation	Independent Variable
Transition from Supply Chain 4.0 to Supply Chain 5.0	Dependent Variable
Sustainability and Resilience	Outcome/Supporting Dimension

9. Statistical Tools Used

Multiple regression analysis, Cronbach's Alpha, Pearson correlation, and descriptive statistics will be used to analyze the gathered data. The features of the respondents will be summarized using descriptive statistics, and the suggested hypotheses will be tested using regression and correlation.

10. Hypothesis Testing

To ascertain whether digital transformation and human-centric digital transformation have a substantial impact on the shift to Supply Chain 5.0, the hypotheses will be assessed at a 5% level of significance ($p < 0.05$).

7. Data Analysis and Interpretation

7.1 Reliability Analysis

Table 4.1: Reliability Statistics (Cronbach's Alpha)

Construct	Items	Alpha	Level
Digital Transformation Technologies	6	0.906	Excellent
Human-Centric Digital Transformation	6	0.900	Excellent
Transition to Supply Chain 5.0	5	0.970	Excellent
Sustainability & Resilience	4	1.000	Excellent

Interpretation: All four constructs recorded Cronbach's Alpha above 0.70 (range 0.90–1.00), confirming excellent internal consistency. Composite (mean) scores were therefore computed and used in subsequent analyses.

7.2 Demographic Profile of Respondents

Table 7.2: Demographic Profile of Respondents (N = 100)

Variable / Category	Frequency	Percent (%)
Age		
Below 25	20	20.0%
35-44	40	40.0%
45-54	40	40.0%
Gender		

Male	60	60.0%
Female	40	40.0%
Respondent Category		
Student	20	20.0%
Supply Chain Professional	80	80.0%
Years of Supply Chain/Logistics Experience		
Less than 2 years	20	20.0%
2–5 years	10	10.0%
6–10 years	20	20.0%
More than 10 years	50	50.0%
Area of Study/Work		
Supply Chain	30	30.0%
Logistics	30	30.0%
Procurement	20	20.0%
Operations	10	10.0%
Manufacturing	10	10.0%

Interpretation: The sample was dominated by experienced supply chain professionals (80%), mostly aged 35–54, with 50% reporting over 10 years of experience- supporting the credibility of responses.

7.3 Descriptive Statistics

Table 7.3: Construct-Level Descriptive Statistics

Construct	Mean	SD	Min	Max
Digital Transformation Technologies (DTT)	4.52	0.51	3.67	5.00
Human-Centric Digital Transformation (HCDT)	4.55	0.46	4.00	5.00
Transition to Supply Chain 5.0 (SC5T)	4.48	0.54	3.60	5.00
Sustainability & Resilience (SSR)	4.40	0.67	3.00	5.00

Interpretation: All constructs recorded high mean scores (above 4.0 on the 5-point scale) with low standard deviations (< 1.0), indicating strong agreement and consensus among respondents regarding digital transformation adoption, its human-centric orientation, the transition to Supply Chain 5.0, and resulting sustainability/resilience gains.

Table 7.3a: Item-Level Descriptive Statistics

Code	Item	Mean	SD
DTT1	Digital technologies are increasingly integrated into supply chain operations.	4.40	0.67
DTT2	Artificial intelligence improves decision-making in supply chain management.	4.70	0.46
DTT3	IoT improves real-time visibility across the supply chain.	4.50	0.67
DTT4	Big data analytics supports better supply chain forecasting and planning.	4.40	0.67
DTT5	Blockchain technology can improve transparency and traceability in supply chains.	4.60	0.49
DTT6	Automation enhances the efficiency of supply chain processes.	4.50	0.67

HCDT ₁	Digital technologies should support rather than replace human decision-making in supply chains.	4.60	0.49
HCDT ₂	Employees are actively involved in the adoption of new digital technologies.	4.40	0.67
HCDT ₃	Human-machine collaboration improves supply chain performance.	4.60	0.49
HCDT ₄	Organizations provide employees with adequate training to use emerging digital technologies.	4.60	0.49
HCDT ₅	Digital technologies enable employees to make faster and better decisions.	4.60	0.49
HCDT ₆	Employee skills and human expertise remain important in digitally transformed supply chains.	4.50	0.67
SC5T ₁	Supply chains are moving from technology-driven approaches towards more human-centric approaches.	4.60	0.49
SC5T ₂	Human-technology collaboration is a key feature of Supply Chain 5.0.	4.50	0.50
SC5T ₃	Organizations are increasingly adopting technologies aligned with human needs and capabilities.	4.40	0.67
SC5T ₄	The transition to Supply Chain 5.0 requires balancing technological efficiency with human capabilities.	4.50	0.50
SC5T ₅	Supply Chain 5.0 provides a more resilient and adaptive approach than Supply Chain 4.0.	4.40	0.67
SSR ₁	Human-centric digital transformation can improve the sustainability of supply chain operations.	4.40	0.67
SSR ₂	Digital technologies help supply chains respond effectively to disruptions.	4.40	0.67
SSR ₃	Supply Chain 5.0 can improve the ability of supply chains to adapt to uncertainty.	4.40	0.67
SSR ₄	Human-technology collaboration contributes to long-term supply chain resilience.	4.40	0.67

7.4 Correlation Analysis

Table 7.4: Pearson Correlation Matrix

Construct	DTT	HCDT	SC5T	SSR
DTT	1.000	0.935**	0.994**	0.980**
HCDT	0.935**	1.000	0.939**	0.875**
SC5T	0.994**	0.939**	1.000	0.975**
SSR	0.980**	0.875**	0.975**	1.000

Note. ** $p < .01$ (2-tailed).

Interpretation: All constructs were positively and significantly correlated ($p < .01$). DTT-SC5T ($r = 0.994$) and HCDT-SC5T ($r = 0.939$) showed strong positive associations, and SC5T-SSR ($r = 0.975$) confirmed the link between the transition and sustainability/resilience outcomes, supporting the move to regression analysis.

7.5 Multiple Regression Analysis and Hypothesis Testing

Multiple regression was conducted with SC5T as the dependent variable and DTT and HCDT

as simultaneous predictors, to test H₁ and H₂.

Table 7.5: Regression Model Summary and Coefficients (DV: SC₅T)

Variable	B	Beta (β)	t	Sig. (p)
(Constant)	-0.401	—	-6.61	< .001
DTT	0.979	0.914	29.28	< .001
HCDT	0.101	0.085	2.73	.007

Model: $R^2 = 0.988$, Adj. $R^2 = 0.988$, $F(2,97) = 4005.27$, $p < .001$. VIF: DTT = 7.90, HCDT = 7.90 (no multicollinearity concern).

Interpretation: DTT and HCDT jointly explained 98.8% of the variance in SC₅T ($F(2,97) = 4005.27$, $p < .001$). Both predictors were statistically significant: DTT ($B = 0.979$, $\beta = 0.914$, $p < .001$) and HCDT ($B = 0.101$, $\beta = 0.085$, $p .007$). Accordingly, H₀₁ and H₀₂ are rejected, and H₁₁ and H₁₂ are supported: both digital transformation technologies and human-centric digital transformation have a significant positive influence on the transition from Supply Chain 4.0 to Supply Chain 5.0, with DTT the stronger predictor.

Table 7.6: Summary of Hypothesis Testing

Hypothesis	Relationship Tested	Decision
H ₀₁ / H ₁₁	DTT → SC ₅ T (no effect / positive effect)	H ₀₁ rejected; H ₁₁ supported
H ₀₂ / H ₁₂	HCDT → SC ₅ T (no effect / positive effect)	H ₀₂ rejected; H ₁₂ supported

7.6 Supply Chain 5.0 Transition and Sustainability & Resilience

To address the third objective, a simple regression of SSR on SC₅T was conducted. The transition to Supply Chain 5.0 significantly and positively predicted sustainability and resilience ($r = 0.975$, $R^2 = 0.950$, $B = 1.202$, $p < .001$), explaining 95.0% of the variance in SSR. This confirms that the transition towards Supply Chain 5.0 contributes to greater supply chain sustainability and resilience.

8. Findings

The study used data from 100 respondents, the majority of whom were seasoned supply chain experts, to investigate the shift from Supply Chain 4.0 to Supply Chain 5.0 through human-centric digital transformation. All four constructs—Digital Transformation Technologies (DTT), Human-Centric Digital Transformation (HCDT), Transition to Supply Chain 5.0 (SC₅T), and Sustainability & Resilience (SSR)—were measured with excellent internal consistency (Cronbach's Alpha above 0.90), according to reliability analysis. With mean scores above 4.0 on the five-point scale and comparatively little variation in replies, descriptive statistics revealed that respondents usually had strong favorable attitudes across all constructs. All constructs showed statistically significant positive correlations, with digital transformation technologies and the shift to Supply Chain 5.0 showing the largest correlation, according to correlation analysis. The null hypotheses (H₀₁ and H₀₂) were rejected while H₁₁ and H₁₂ were supported after multiple regression analysis revealed that DTT and HCDT together explained 98.8% of the variation in the shift to Supply Chain 5.0 and that both were statistically significant predictors. The third goal of the study was further supported by an additional analysis, which showed that the shift to Supply Chain 5.0 significantly predicts sustainability and resilience results. When considered collectively, the results show that the adoption of

digital technology and its human-centric focus are important forces behind the transition to Supply Chain 5.0, which in turn improves supply chain resilience and sustainability.

9. Recommendations

- Continue investing in core digital technologies (AI, IoT, big data analytics, automation) as key drivers of the Supply Chain 5.0 transition.
- Design digital systems that support, not replace, human decision-making.
- Provide structured training and upskilling to help employees adapt to new technologies.
- Involve employees actively in technology adoption decisions to strengthen engagement.
- Frame digital transformation strategy around resilience and sustainability, not just efficiency.
- Encourage policymakers to support incentives for human-centric digitalization.
- Periodically reassess digital maturity, as the transition is an ongoing process.

10. Scope

This study offers practical value across multiple stakeholder groups:

- Companies/Industry Practitioners - Guides investment in digital technologies while balancing automation with human-centric practices to strengthen resilience and sustainability.
- Researchers/Academics - Provides empirical validation of Supply Chain 5.0 and a tested framework for future research in this emerging area.
- Government/Policy Institutions - Informs policies and incentives that promote human-centric digitalization and workforce development.
- Students/Academic Institutions - Serves as a reference for learning and further research on digital transformation and Supply Chain 5.0 concepts.
- Society - Highlights how human-centric, resilient supply chains help reduce disruptions and support long-term sustainability.
- Employees/Workforce - Reinforces the continued value of human skills and supports the case for training in a digitally transforming workplace.

11. Conclusion

With three goals and two hypotheses in mind, this study set out to investigate the shift from Supply Chain 4.0 to Supply Chain 5.0 from the perspective of human-centric digital transformation. The findings confirm that both technological capability and human-centered design are essential elements of the shift to Supply Chain 5.0, as digital transformation technologies play a significant and dominant role in enabling this transition, while human-centric digital transformation makes a smaller but still statistically significant contribution. The study also discovered compelling evidence that this shift is strongly linked to enhanced supply chain resilience and sustainability, bolstering the more general idea that Supply Chain 5.0 is a more flexible and balanced paradigm than its predecessor. These results support the literature's claim that the future generation of supply chains must actively incorporate human knowledge, teamwork, and well-being in addition to digital innovation. From a theoretical perspective, by empirically confirming the linkages between its fundamental enabling aspects, the study adds empirical credence to the growing discourse on Supply Chain 5.0. In practical terms, it provides policymakers and supply chain managers with a better foundation for setting priorities for investments in people and technology during this shift. These findings would be strengthened and expanded upon in subsequent studies that draw on a larger, more varied sample and use qualitative or longitudinal methods.

12. Reference

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