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The Implications of Smart Supply Chain and Digital Orientation on Environmental Performance: The Moderating Role of Eco-centricity

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Gladys Tuo
School of Business, Kumasi Technical University, Ghana
Email: gladys.tuo@kstu.edu.gh

Michael Karikari Appiah
School of Sustainable Development,
University of Environment and Sustainable Development, Ghana
makarikari@uesd.edu.gh

James Yaw Osei-Owusu
Faculty of Business, Koforidua Technical University, Ghana
Email: jamesceegha@gmail.com

&

Aloysius Sam
Department of Building Technology,
Kumasi Technical University, Kumasi, Ghana
Aloysius.sam@kstu.edu.gh

Abstract

This paper discovers the impact of smart supply chains and digital orientation on environmental performance in Ghana's manufacturing sector, highlighting the moderating role of eco-centricity. Despite the technological developments associated with the 4th Industrial Revolution, many emerging countries, including Ghana, have slowly adopted these innovations. Through a quantitative, survey-based study involving 245 Ghanaian supply chain firms, the research uses Structural Equation Modelling (SEM) with SMART-PLS software to test its hypotheses. The findings show that smart supply chains and digital orientation positively influence environmental performance, with eco-centricity further strengthening the link between digital orientation and sustainability outcomes. The study offers valuable insights for academics, policymakers, and industry practitioners, suggesting strategies to enhance environmental performance through smart technologies and eco-focused strategies within resource-limited contexts.

Keywords: *Smart Supply Chain, Digital Orientation, Environmental Performance, and Eco-centricity.*

Introduction

With the advent of the Fourth Industrial Revolution, innovations and technological capabilities have emerged in supply chains, including high connectivity, automation, advanced analytics, and modern manufacturing technologies. The increasing complexities in global supply chains, driven by technological advancements and environmental challenges, have created a pressing need for smart supply chain management systems. Traditional supply chain models are often inefficient, lacking the agility and responsiveness necessary to meet dynamic market demands while addressing environmental concerns (Dzhuguryan and Deja, 2021; Liu et al., 2022; Wang et al., 2022; Liu et al., 2023).

Despite the rise of digital technologies such as IoT, AI, and blockchain, many organizations struggle to integrate these tools effectively into their supply chain operations. This lack of digital orientation not only hinders operational efficiency but also impedes their ability to enhance environmental performance (Ivanov et al., 2020). Furthermore, the absence of an eco-centric approach in supply chain management often results in unsustainable practices that exacerbate resource depletion, greenhouse gas emissions, and waste generation, undermining global efforts toward achieving environmental sustainability (Wu et al., 2016; Dubey et al., 2017; Wan and Qie, 2019; Silva et al., 2019; Varghese, 2024).

While the concept of smart supply chains (SSCs) holds significant promise for improving both operational and environmental outcomes, its adoption remains uneven, particularly in emerging markets. Many organizations face barriers such as high implementation costs, limited technical expertise, and insufficient policy support for eco-centric practices (Bag et al., 2020). Moreover, there is a growing disconnect between the pursuit of profitability and environmental sustainability, as businesses often prioritize short-term gains over long-term ecological benefits (Esfahbodi et al., 2016; Cocks and Simpson, 2015; Appiah et al., 2022; Jebari and Sandberg, 2022; de Figueiredo and Marquesan., 2022; Zhou et al., 2023). As a result, the potential of digital orientation to drive environmental performance and promote eco-centric supply chain strategies remains largely untapped. Addressing this gap requires a comprehensive understanding of the interplay between smart technologies, digital orientation, and environmental objectives, as well as actionable frameworks for integrating these elements into supply chain management. Without this, the transition to environmentally responsible and technologically advanced supply chains will remain a significant challenge for businesses globally (Gupta et al., 2019; Liu et al., 2021; Liu et al., 2022; Wang et al., 2022; Liu et al., 2023).

In addition, SSCs are networks of connected and intelligent devices, systems, and processes that enable data collection, analysis, and optimisation. In addition, SSC leverages technologies such as the Internet of Things, artificial intelligence, cloud computing, blockchain, and robotics to improve supply chain transparency, flexibility, efficiency, and sustainability The context of this study focuses on how SSC ensures environmental sustainability in the digital era. Furthermore, digital orientation (DO) entails the deliberate adoption of strategic thinking characterised by positive attitudes and manifested in an organization through actions and behaviours that support active innovation (Jawahar et al., 2015; Quinton et al., 2017; Abdel-Basset, 2018; Davydov, 2022; Vargas-Hernández et al., 2023).

This paper aims to address this knowledge gap by developing a baseline model wherein smart supply chain and digital orientation derive environmental performance with a moderating role of eco-centricity in a low-resource context. Theoretically, the study has developed a baseline model that could be used to enhance the theoretical understanding of SSCs, digital orientations, and environmental performance. The newly developed model offers high predictability and pragmatism to the constructs being studied. The model has indicated and explained how a firm's adoption of smart supply chain principles could be used to determine the environmental performance of manufacturing companies operating in Ghana and the extent to which eco-centricity mediates this relationship. Moreover, the model emphasizes the unique moderating role of digital orientations on the relationship between SSCs and environmental performance, focusing on a lower middle-income country.

Regarding policy and practices, the study offers unique contributions to academicians, policymakers, and practitioners on utilising smart supply chains and digital orientation to maximize environmental performance. Moreover, policymakers could regulate the activities and operations of manufacturing companies to adopt best practices that could enhance operational commitment towards the attainment of Sustainable Development Goals (SDGs), particularly SDGs 12 and 13, respectively, on responsible consumption and production and actions to mitigate against climate change. Again, the paper has established that eco-centricity plays an important role in environmental sustainability in the era of Industry 4.0. The study has included six parts of this report, which start with the introduction and end with conclusions. Part 2 focuses on literature review and hypotheses development, part 3 focuses on methodology, part 4 focuses on results, part 5 focuses on discussions, and the final part presents the conclusion, implications, limitations, and suggestions for the future of the study.

Literature Reviews and Hypotheses Development

Theoretical Review and the Hypotheses Development

The current study is situated in two theories: Namely, the Natural Resource-Based View Theory (NRBV) and the Diffusion of Innovation Theory (DOI). Firms' ability to continuously improve and optimize production processes can lead to reduced emissions and costs (Hart, 1995), and the ability to be strategically proactive can lead to innovative advantages and more proactive environmental management (Aragon-Correa et al., 2008, p. 92; García Martín et al., 2019; Gilal et al., 2019; Anwar, et al., 2020; Kraus et al., 2020; Li et al., 2020; Rehman, et al., 2021). Moreover, the NRBV theory has complemented the DOI theory to explain further how innovation, such as a smart supply chain, could be leveraged to attain environmental sustainability through digitalization orientation. The DOI is based on the fact that new ideas (innovations) or technologies are constantly emerging and that orientations of these innovations are crucial for the diffusion of innovations in a society or organization. Besides, DOI attempts to explain why and how quickly new ideas and technologies spread or diffuse across cultures (Al-Qahtani & Wamba, 2012; Arias-Perez and Velez-Jaramillo, 2022). The DOI theory incorporates various attributes of innovation, such as comparative advantage, compatibility, inclusiveness, verifiability, and replicability (Comer & Kendall, 2013), which allows this theory to guide and facilitate the decision-making process during the diffusion of innovation in an environment. According to the DOI theory, the decision-making process for innovation consists of five phases: Informing, persuading, deciding, implementing, and validating the innovation (Sang & Tsai, 2009). Figure 1 presents the research framework developed based on the outlined theories.

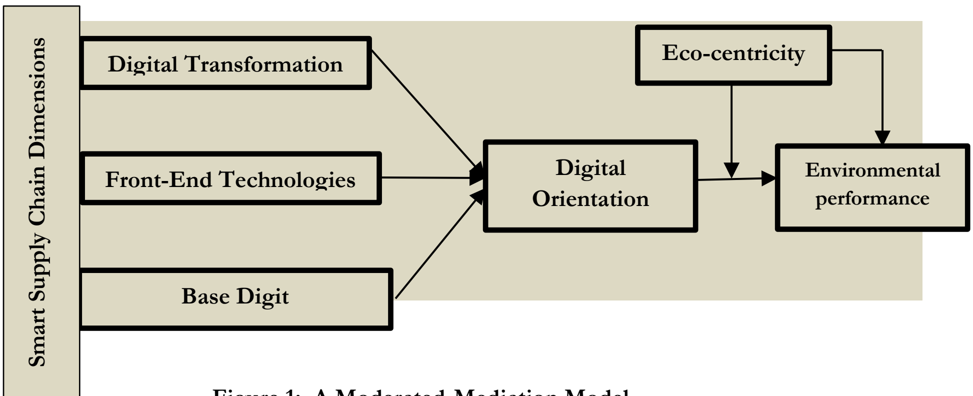

Figure 1: A Moderated-Mediation Model

Smart Supply Chains (SSC) and environmental performance

Smart Supply Chain (SSC) is an emerging concept broadly used to define a supply chain management system that uses advanced technology and automated data analysis to optimise the flow of goods and services from suppliers to consumers. In addition, SSC represents an innovative approach to supply chain management that uses various computer-based methods to automate different aspects of the process (Abdel-Basset, 2018; Davydov, 2022). SSC also refers to a modern, interconnected business system that ranges from stand-alone, local, and single-firm applications to a wide range across the supply chain. The SSC represents an innovative approach to supply chain management that uses various computer-based methods to automate different aspects of the process (Abdel-Basset, 2018; Davydov, 2022), with systematic applications throughout the supply chain. In addition, SSCs are interconnected intelligent networks of equipment, systems, and processes that enable real-time data collection, analysis, and optimization of supply chain operations. SSCs are modern networked business frameworks focusing on systematic supply chain applications instead of local models.

Moreover, Al-Mulhim (2021) explains that supply chain management involves using statistical data to manage complexity and risk from planning to decision-making. In conclusion, supply chain management is a key trend in the manufacturing industry that aims to strengthen core competencies by improving product and service quality, increasing productivity, and promoting innovation, green practices, and coordination. In addition, SSC has six characteristics: instrumental, connected, intelligent, automated, integrated, and innovative (Wu et al., 2016). This study suggests that SSC exerts innovational capabilities that could be used to transform an organization through competitive advantage development. Based on this exclusive position of the paper, the authors have proposed as follows:

$H_{1\text{-}3}$: *Smart supply chain practices (digital transformation, front-end technologies, and base digit) positively and significantly relate to the digital orientation*

Digital orientation (DO) and environmental performance

Digital orientation is a guiding principle that organizations follow to take advantage of the opportunities offered by digital technologies and gain a competitive advantage. It includes dimensions such as the scope of digital technologies, digital capabilities, coordination of the digital ecosystem, and configuration of the digital architecture. In addition, DO provides strategic guidance for organizations in developing and implementing specific digital strategies and selecting appropriate digital initiatives (Kindermann et al., 2020). Similarly, DO is considered a strategic business direction that focuses on changes triggered by digital technologies such as social networks, mobile applications, and digital processes (Rupeika-Apoga et al., 2022). Similarly, Khin and Ho (2019) define DO as an indicator of a firm's commitment and openness to embrace digital technologies in digital transformation initiatives. In addition, DO plays a role in addressing the uncertainty associated with risky projects such as deep digital transformation (Eggers and Park, 2018). Finally, DO aims to provide helpful information about digital technologies and create a knowledge framework for digital transformation (Dinh Khoi et al., 2020). To this point, the study proposes as follows:

H4: Digital orientation positively and significantly relates to environmental performance

H6: Digital orientation significantly mediates the relationship between smart supply chain and environmental performance

Ecocentrism and environmental performance

Ecocentrism is defined as a characteristic of a business that takes into account the welfare and potential learning benefits that the business receives from its wider environmental partners (Chavez, Yu, Feng, & Wiengarten, 2016; Gold et al, 2013). Ecocentrism is the esoteric belief that humans are not the center of the universe but part of the balance of nature (Cocks and Simpson, 2015). Moreover, ecocentrism goes beyond biocentrism (an ethic that believes all living things have intrinsic value) to encompass the environmental system and its abiotic aspects. In addition, ecocentrism encourages firms to engage with competitors, community members, and NGOs that are ignored or considered enemies in traditional channels (Zhu et al, 2013). Furthermore, Allen et al. (2017) explain the existence of ecocentrism as a serious concern for environmental issues. Ecocentrism believes that the ecosphere (comprising all ecosystems, the earth's atmosphere, water, and soil) is the mother of all life and the sole source of nutrients. Ecocentrism also regards nature as a moral entity with its laws and values. It recognizes the intrinsic value of all life forms and ecosystems, regardless of their usefulness to humans (Wu et al., 2016; Abdel-Basset, 2018, AlMulhim, 2021; Davydov, 2022). Ecocentricity relates to environmental performance in many folds. In the light of the above presentations, the study proposes as follows:

H5: Eco-centricity positively and significantly relates to environmental performance

H7: Eco-centricity significantly moderates the relationship between smart supply chain and environmental performance

Research Methodology

Research design and model

This study is anchored to the positivist research paradigm. This is because the study is associated with the application of numerical and mathematical models, which is consistent with the hypothetico-deductivism method wherein hypotheses are formulated based on theories, and these hypotheses are tested using real-life data to establish the reality (Cohen, Manion, Morrison, 2017; Creswell and Creswell, 2018; Buckler and Moore, 2023). It is worth noting that Saunders et al. (2012) point out that all research methods that use a deductive approach to theory development fall within the positivism paradigm. Besides, we have approached this study with an explanatory design due to the relationship between the causes and effects in the model (Creswell and Creswell, 2018; Buckler and Moore, 2023). The model explains how much changes in smart supply chain practices are required to cause a change in environmental performance, and the extent to which the digital orientation could be used to strengthen or weaken this relationship has also been explored. As a result, this study employed a research design in which numerical data was collected and tested through structured questionnaires. The analyses have been conducted with the aid of Smart-PLS version 3.8.9. The hypotheses were tested using standard beta coefficients and t-values. Again, a survey strategy employed in this study elicits the shared opinions and perceptions of a defined group of people, which can then be generalized to the population.

Target population and sampling procedure

The target population for this study is private sector entities involved in manufacturing companies in Ghana. Specifically, the study is limited to private entities in the Greater Accra Region of Ghana. Three main inclusion criteria were used in the selection of the participants. Namely, i) all the participating companies must be a number of the following: a) Association of Ghana Industries, b) Ghana Enterprise Agency, and c) Ghana Chamber of Commerce and Industry. ii) The participating companies should have been in business for five years or better. Finally, iii) the company must be fully or wholly Ghanaian-owned. The target groups are supply chain/procurement officers, executive directors/department heads (managers), accountants, finance officers, internal auditors, warehouse managers, and transport and distribution managers. The decision to use the selected locations (regions) was based on the fact that Accra is the administrative capital of Ghana, and all government offices are located in this region. In addition, people from different cultural groups live in this area, so the responses can reliably reflect the views of most of the population. On the other hand, the Ashanti region is a business hub in a nodal town serving as a link between Ghana's northern and southern economies. Ghana's centralized system also ensured the availability of data. The survey's sample size was determined based on ten (10) rules. This sampling method was developed by Hair et al. (2011). As shown in Figure 1, there are 12 pathways, of which 6 are direct and 6 are indirect. Therefore, 120 (10*12) minimum survey sample size were required for the study. Meanwhile, 245 useable responses were used in the study.

Data collection instruments, data sources, and measurement scales

The main source of data for this study was primary data. A structured questionnaire was used, the instrument of which was developed based on several constructs drawn from empirical and theoretical literature. Theoretical approaches such as dynamic capability theory and diffusion of innovation theory were used in this study. In addition, all the constructs were adapted and pre-tested before use. For example, environmental performance was adopted from Appiah et al. (2022), and digital orientation (DO) was measured based on the findings of Kindermann (2020) and Khin and Hu (2019), ecocentricity was adopted from Appiah et al. (2022) while smart supply chain measures were adopted from Varghese (2024). The measure consists of two parts: The first part focuses on demographic data, which was measured using a categorical scale; the second part describes the main constructs of the model, such as smart supply chain, digital orientation, eco-centricity, and environmental performance. These constructs are measured on a five-point Likert scale. The data collection instrument was distributed to respondents via a personalized Google form. The two methods are complementary when used together. Respondents who could not meet in person could complete and submit the survey via the Google form. 500 questionnaires were distributed in 2022, 230 in person and 270 online. A total of 245 usable responses were received.

Common Method Biases

Common Method Bias (CMB) refers to underlying judgments and decisions that affect the validity and reliability of the measurement instrument and, thus, the overall results of the model. Podsakoff and MacKenzie (Podsakoff and MacKenzie, 2012) also argue that CMB can lead to negative results if it is not identified in time. Several measures were introduced to account for bias in the CMB model. Previously, measurement instruments were validated in different forms, such as content validity, structural validity, and explicit validity. In addition, a Harman one-way test was conducted using SPSS software version 21 to assess the presence of BMPs. Overall, the results showed that the one-way model could explain 28.1% of the variance in the outcome variable, which is below the threshold of 50%. Thus, the authors concluded that there was no CMB problem in this study.

Data Analysis

This study used Intelligent Partial Least Square (PLS) software version 3.8.9 to analyze and test the research hypotheses. The main regression technique used in this study is called Structural Equation Modeling (SEM). This technique can be used to solve multiple problems simultaneously. An advantage of SEM over ordinary squares (OLS) is that it is a second-generation tool that allows using latent variables in regression with very low estimation errors. This saves time and gives reliable results. The SEM models used in this paper are divided into two categories: measurement models and structural models. To assess the convergent validity of the models, Cronbach's alpha, factor loadings, composite reliability, and mean signal variance were determined, while discriminant validity was assessed using cross-loadings, mean signal variance, and heterotrait-monotrait ratio (HTMT). The second part focuses on the structural model, which mainly consists of path coefficients, T-values, R-squares, and Q-squares.

Results

Descriptive Statistics, Normality Test and Variance Inflatory Factor (VIF.)

Table I presents the results of the descriptive statistics, normality test, and variance inflation factor. Specifically, mean values, median values, standard deviations, and minimum and maximum values have been used to present descriptive results. The results have shown that the means and standard deviation values are fairly distributed, with mean scores between 3.678 and 3.922 and standard deviation scores between 0.915 and 1.078. These results suggest that the majority of the respondents agree with the measurements. Meanwhile, most of the standard deviation scores are greater than one (e.g., SD scores >1), suggesting high variations among the respondents concerning their opinions on the issues under investigation. The normality of the distribution was assessed using kurtosis and skewness scores. The results have shown that the kurtosis scores ranged between -0.005 to 1.163, while skewness scores ranged between -0.522 to -1.072. These results have shown that the scores for kurtosis are less than seven (±7) and that of skewness are less than two (±2).

Table I: Descriptive Statistics, Normality Test and Variance Inflatory Factor (VIF.)

	Mean	Median	Min	Max	Std. Deviation	Kurtosis	Skewness	VIF
BDT1	3.882	4.000	1.000	5.000	0.932	-0.219	-0.611	2.735
BDT2	3.880	4.000	1.000	5.000	0.915	0.307	-0.671	3.964
BDT3	3.810	4.000	1.000	5.000	1.078	-0.367	-0.625	1.829
BDT4	3.760	4.000	1.000	5.000	1.054	-0.351	-0.619	4.311
BDT5	3.752	4.000	1.000	5.000	1.054	0.110	-0.736	4.723
DO1	3.832	4.000	1.000	5.000	0.988	-0.186	-0.657	2.520
DO2	3.822	4.000	1.000	5.000	1.015	0.351	-0.858	4.024
DO3	3.828	4.000	1.000	5.000	0.987	-0.192	-0.651	1.884
DO4	3.870	4.000	1.000	5.000	0.947	0.344	-0.744	2.236
DO5	3.886	4.000	1.000	5.000	0.936	-0.251	-0.606	2.913
DTS1	3.912	4.000	1.000	5.000	0.959	-0.243	-0.614	1.603
DTS2	3.832	4.000	1.000	5.000	0.988	-0.186	-0.657	1.332
DTS3	3.822	4.000	1.000	5.000	1.015	0.351	-0.858	4.208
DTS4	3.864	4.000	1.000	5.000	0.962	1.163	-1.009	1.777
DTS5	3.870	4.000	1.000	5.000	0.947	0.344	-0.744	1.889
ECO1	3.880	4.000	1.000	5.000	0.915	0.307	-0.671	3.540
ECO2	3.836	4.000	1.000	5.000	0.984	-0.005	-0.701	3.818
ECO3	3.912	4.000	1.000	5.000	1.016	0.493	-0.913	1.368
ECO4	3.914	4.000	1.000	5.000	0.961	-0.248	-0.615	1.414
ECO5	3.832	4.000	1.000	5.000	0.988	-0.186	-0.657	4.178
ECO6	3.882	4.000	1.000	5.000	0.974	1.072	-1.000	1.785
EP1	3.678	4.000	1.000	5.000	1.106	-0.644	-0.522	4.254
EP2	3.864	4.000	1.000	5.000	1.026	-0.456	-0.593	3.525
EP3	3.748	4.000	1.000	5.000	1.053	-0.169	-0.648	2.579
EP4	3.786	4.000	1.000	5.000	1.034	0.070	-0.707	2.204
EP5	3.706	4.000	1.000	5.000	1.097	-0.645	-0.537	2.331
EP6	3.780	4.000	1.000	5.000	1.095	-0.290	-0.655	4.147
FET1	3.874	4.000	1.000	5.000	0.993	0.201	-0.765	2.850
FET2	3.858	4.000	1.000	5.000	0.964	0.137	-0.679	2.603
FET3	3.770	4.000	1.000	5.000	1.034	-0.391	-0.606	2.151
FET4	3.814	4.000	1.000	5.000	1.062	-0.250	-0.689	2.090
FET5	3.808	4.000	1.000	5.000	1.031	-0.295	-0.630	2.459

Note: BD=Base Digital, DO=Digital Orientation, DT=Digital Transformation, ECO=Eco-centricity, EP=Environmental Performance, FET=Front-End Technologies

Measurement Model – Convergence Validity and Discriminant Validity (Construct Validity)

Tables II and III present results on convergence and discriminant validities. The convergence validity has been assessed through composite reliability (CR), Cronbach alpha (CA), Average variance extracted (AVE), and item loadings. Specifically, all the various outlined tests must attain a minimum acceptable score of 0.70 or better except AVEs, which are expected to score 0.50 or better. The results showed that CR scores ranged between 0.919 to 0.955, CA scores ranged between 0.889 and 0.940, AVEs scores ranged between 0.695 and 0.725, and item loading, as shown in Figure 2, ranged between 0.75 and 0.976. All these scores are within the acceptable minimum scores and, in most cases, exceed the minimum requirements. Ultimately, the model has met the requirements for acceptable convergence validity. Nevertheless, discriminant validity has been assessed using two different approaches. Namely, Fornell-Larcker (1981) Criterion and Heterotrait-Monotrait Ratio (HTMT). Using the Fornell-Larcker (1981) Criterion the AVEs scores were squarely rooted and then correlated with the main constructs of the study. The results have shown that the squared root values are higher than the correlation values. Besides, the scores of the Heterotrait-Monotrait Ratio, as shown in Table III, further confirm that the model has met the requirements for discriminant validity.

Table II: Discriminant Validity and Reliability using Fornell-Larcker (1981) Criterion

	CA	Rho_A	CR	AVE	BD	DO	DT	ECO	EP	FET
BD	0.889	0.894	0.919	0.695	***0.834***					
DO	0.940	0.941	0.955	0.811	0.875	***0.901***				
DT	0.904	0.904	0.929	0.725	0.905	0.939	***0.851***			
ECO	0.915	0.915	0.934	0.701	0.920	0.903	0.983	***0.837***		
EP	0.929	0.930	0.944	0.739	0.855	0.772	0.826	0.846	***0.860***	
FET	0.894	0.896	0.922	0.702	0.494	0.437	0.471	0.475	0.556	***0.838***

Note: The Square Root of the AVE is italics in the diagonal. CA=Cronbach Alpha, CR=Composite Reliability, AVE=Average Variance Extracted, BD=Base Digital, DO=Digital Orientation, DT=Digital Transformation, ECO=Eco-centricity, EP=Environmental Performance, FET=Front-End Technologies

Table III: Heterotrait-Monotrait Ratio (H.T.M.T.) Henseler Criteria

	BD	DO	DT	ECO	EP	FET
Base Digital						
Digital Orientation	0.963					
Digital Transformation	1.007	1.017				
Eco-centricity	1.017	0.971	1.081			
Environmental Performance	0.940	0.823	0.898	0.915		
Front-End Technologies	0.553	0.475	0.523	0.524	0.609	

Note: BD=Base Digital, DO=Digital Orientation, DT=Digital Transformation, ECO=Eco-centricity, EP=Environmental Performance, FET=Front-End Technologies

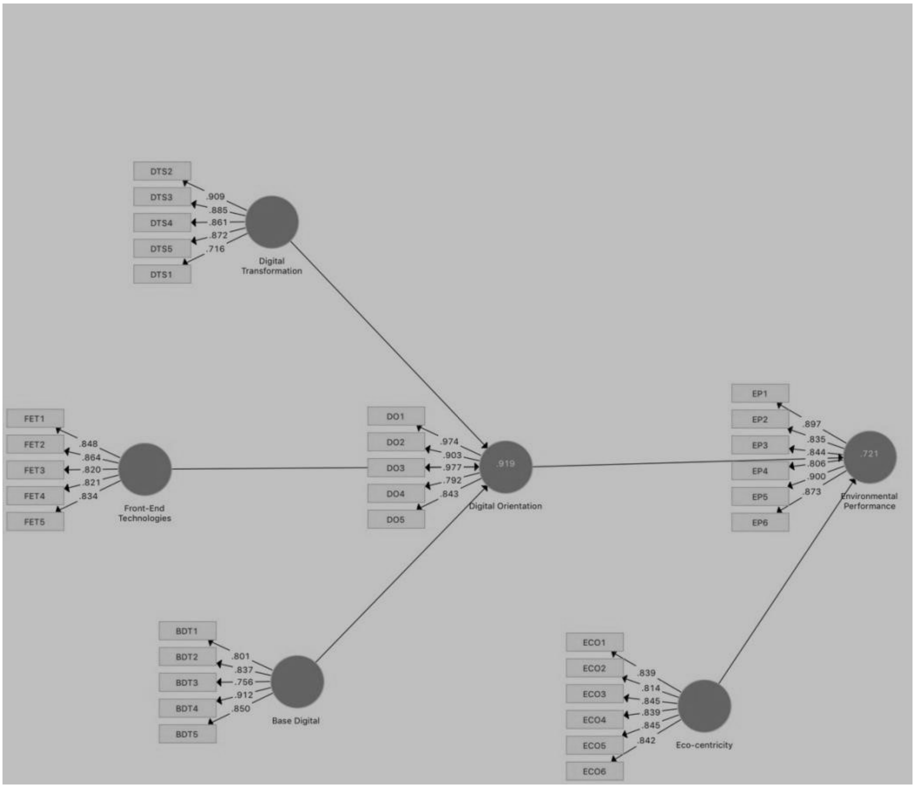

Figure 2: Item Loadings

Structural Model

Construct Cross-validated Redundancy (Q^2) and R-square (Adj.R^2)

This section presents two important information. The first part presents results on constructs-cross-validated redundancy and R-square scores, while the second part presents results on the hypotheses testing and path co-efficient. As shown in Table IV, the results have shown that the model has very strong predictive power ranging between 72.1 to 91.9 per cent. The results imply that smart supply chains, ecocentricity, and digital orientation strongly impact environmental performance. Again, the predictive relevance of the model has been assessed using Construct Cross-validated Redundancy (Q-square). The Q-square values ranged from 0.527 to 0.677, far greater than zero.

Table IV: Construct Cross-validated Redundancy and R-square (Adj.R^2)

	SSO	SSE	Q^2 (=1-SSE/SSO)	R^2	Adjusted R^2
Base Digital	2500.000	2500.000			
Digital Orientation	2500.000	2500.000		0.919	0.919
Digital Transformation	2500.000	2500.000			
Eco-centricity	3000.000	970.406	.677	0.972	0.972
Environmental Performance	3000.000	1419.359	.527	0.721	0.720
Front-End Technologies	2500.000	2500.000			

Path Coefficients and Hypotheses Testing

Table V presents results on path coefficients and hypotheses testing. The results have shown that digital transformation (beta= 0.832, t-statistics=28.993), front-end technologies (beta= 0.101, t-statistics=3.332), and based digit (beta= 0.167, t-statistics=5.252) have significant effects on environmental performance. The study has revealed that digital orientation and ecocentricity have significant effects on environmental performance. Regarding the mediating effects, the study has revealed that digital orientation significantly mediates the relationship between smart supply chain dimensions such as digital transformation (beta= 0.717, t-statistics=9.406) and base digit (beta= 0.144, t-statistics=4.286) environmental performance. Moreover, the study has revealed that ecocentricity significantly and positively (beta= 0.103, t-statistics=3.443) moderates the relationship between digital and environmental orientation.

Table V: Path Coefficients and Hypotheses Testing

HYPOTHESIZED-PATH	ORIGINAL SAMPLE	MEAN	STD DEVIATION	T STATISTICS	P VALUES
		DIRECT EFFECT			
H1: DT -> EP	0.832	0.833	0.029	28.993	0.000
H2: FET -> EP	0.101	0.106	0.032	3.332	0.001
H3: BD -> EP	0.167	0.165	0.032	5.253	0.000
H4: ECO -> EP	0.157	0.155	0.033	5.555	0.000
H5: DO -> EP	0.862	0.863	0.092	9.361	0.000
		MEDIATING EFFECTS			
H6A: DT -> DO -> EP	0.717	0.719	0.076	9.406	0.000
H6B: BD -> DO -> EP	0.144	0.143	0.033	4.286	0.000
H6C: FET -> DO -> EP	0.001	0.002	0.009	0.101	0.920
		MODERATING EFFECT			
H7: DO*ECO -> ERP	0.103	0.105	0.030	3.443	0.001

Discussions

The advent of Industry 4.0 has intensified supply chain operations in terms of innovations and technological capabilities, including high connectivity, automation, advanced analytics, and advanced – manufacturing technologies. Contrariwise, developing these capabilities in most emerging countries like Ghana has been sluggish. This paper aimed to create a baseline model to explain the relationship between smart supply chain, digital orientation, ecocentricity, and environmental performance in the Ghanaian context. Specifically, the study has examined the effects of smart supply chains on environmental performance, the moderating role of ecocentricity on the relationship between digital orientation and environmental performance, and the mediating role of digital orientation on the relationship between smart supply chains and environmental performance. The results have been discussed in detail below:

For objective one, the study has revealed that smart supply chain dimensions such as digital transformation, front-end technologies, and based digits significantly affect environmental performance. These results are consistent with previous studies (refer to; Su et al., 2018; Gupta et al., 2019; Azizi et al., 2021; Liu et al., 2021; Dzhuguryan and Deja, 2021; Liu et al., 2022; Wang et al., 2022; Liu et al., 2023). Gupta et al. (2019) explained the relationship between smart supply chain and information system agility to make the entire supply chain more agile. This study extends the application of OIPT theory for a better understanding of analytical computation and theoretically based recommendations for managers to achieve greater agility in dynamic environments. Moreover, Veeriyasitavat et al. (2022) discussed a smart manufacturing model that supports intelligent supply chains with self-organizing and self-optimizing capabilities to cope with unpredictable situations. The challenge for traditional supply chains is to optimize supply processes and reduce the total cost of goods and services. The emerging Internet of Things, cyber-physical systems, and blockchains have created a foundation to support interoperability that meets supply chains' scalability, security, flexibility, and agility requirements.

Concerning the second objective, the study has revealed that ecocentricity significantly and positively moderates the relationship between digital orientation and environmental performance. These results are consistent with previous studies (Kopnina et al., 2018; Humaida, 2019; Agyabeng-Mensah et al., 2021; Bataineh., 2021;

Gochuico., 2021; Appiah et al., 2022; Jebari and Sandberg, 2022; de Figueiredo and Marquesan., 2022; Laguir, et al., 2022; Zhou et al., 2023). Agyapeng-Mensah et al. (2021) assessed the impact of environmental orientation, green logistics, and supply chain traceability of smart supply chains on sustainability performance. The results of the analysis showed that global logistics management systems have a positive impact on social and environmental sustainability. However, global GSCM systems hurt business performance. The results show that green logistics and supply chain traceability increase the ability of global logistics to achieve significant improvements in both business performance and environmental sustainability through a mediated outcomes approach. Appiah et al. (2022) examined the relationship between green supply chain management practices and environmental performance. They developed an integrated model that explains the mediating role of environmental intermediation in the relationship between green supply chain management practices and environmental performance in the post-oil industrial context of Ghana. The study developed a new integrated model to optimize the adaptation and adoption of green supply chain management practices in oil and gas marketing and distribution firms. Hamida (2019) identified the role of ecocentrism to environmental awareness for sustainable use of natural resources. People may have the same level of environmental awareness but different environmental ethics. Ecocentrism should be further promoted among scientists to achieve sustainable use of natural resources for the present generation and the next generation.

Regarding the final objective, the mediating effects, the study has revealed that digital orientation significantly mediates the relationship between smart supply chain dimensions such as digital transformation and base digit environmental performance. These results are consistent with previous studies (Dantsoho et al., 2020; Nasiri et al., 2022; Tucmeanu et al., 2022; Chavez et al., 2023; Li and Shao, 2023; Maurer et al., 2023; Ranjan, 2023; Xu et al., 2023). Nasseri et al. (2022) examined three relatively basic elements of digital transformation (digital orientation, digital intensity, and digital maturity) and their impact on the financial performance of organizations. Five hypotheses were developed based on the literature on strategic management and digital transformation to examine the relationship between these antecedents and financial success. Digital orientation and digital intensity alone do not affect the financial performance of organizations. Kopalle et al. (2020) showed how traditional organizations can take advantage of the digital ecosystem and emerging capabilities in digital customer orientation. The authors present a framework for traditional organizations to develop digital customer centricity in three steps: (1) how digital companies such as Amazon, Google, and Facebook are leveraging digital ecosystems, providing insight into how they are doing so; (2) describing how traditional companies can leverage this knowledge to exploit the digital ecosystem and develop an approach to digital customer centricity, outlining the organizational characteristics needed for development and integrating them into a marketing policy framework.

Conclusions, Implications, and Future Studies

Conclusion

The 4th industrial revolution has propelled supply chain operations with innovations and technological capabilities, including high connectivity, automation, advanced analytics, and advanced – manufacturing technologies. However, the development of these capabilities in most emerging countries, such as Ghana, has been sluggish and least explored. This was conducted to develop a baseline model wherein a smart supply chain and digital orientation derive environmental performance with a moderating role of eco-centricity in a low-resource context. The results have shown that smart supply chains and digital orientation significantly affect environmental performance. Besides, the relationship between digital orientation and environmental performance is significantly moderated by eco-centricity. The study concludes that a smart supply chain strongly influences environmental performance through digital orientation. Besides, eco-centricity strengthens the relationship between digital orientation and environmental performance as a moderator.

Implications – Theories and Practices

This study has implications for academicians, policymakers, and practitioners in utilizing smart supply chains and digital orientation to maximize environmental performance. Again, the paper has established that eco-centricity plays an important role in environmental sustainability in the era of Industry 4.0. From a theoretical perspective, the study has developed a set of principles that can be used to improve the theoretical understanding of smart supply chain, digital orientation, and environmental performance. The newly developed model offers a high degree of predictability and realism for the constructs being studied. The model has demonstrated and explained how the environmental performance of manufacturing companies operating in Ghana can be determined by adopting smart supply chain principles and the extent to which environmental orientation mediates this relationship. Moreover, the model highlights the unique moderating role of digital orientation in the link between smart supply chain and environmental performance, focusing on a low- and middle-income country. From a policy and practice perspective, the study uniquely contributes to academics, policymakers, and practitioners leveraging smart supply chains and digital orientation to maximize environmental performance. In addition, policymakers could regulate the activities and operations of manufacturing companies to adopt best practices that could increase companies' commitment to the SDGs, particularly SDGs 12 and 13, on responsible consumption and production and climate change mitigation measures. The study has also established that environmental orientation plays an important role in achieving environmental sustainability in the era of Industry 4.0.

Limitations, Delimitations and Suggestions for Future Studies

This study has been conducted to develop a baseline model wherein smart supply chain and digital orientation derive environmental performance with a moderating role of eco-centricity in a low resource context with a focus on manufacturing companies in Ghana using cross-sectional data and a deductive approach to theory development. The study suggests that future studies should consider other sectors of the economy. Moreover, longitudinal data is strongly recommended to allow trends and long-term relationships to be determined. Again, there is a need to expand the current study beyond Ghana to other emerging countries in Africa, Asia, and Southern American countries. This study focuses on the intersection of smart supply chain management, digital orientation, environmental performance, and eco-centricity, specifically within the context of medium to large-scale organizations operating in emerging markets. The scope is delimited to analyzing how digital technologies such as IoT, blockchain, and AI are integrated into supply chains to enhance environmental sustainability. It does not extend to other aspects of supply chain management, such as financial performance or labor practices unless they directly relate to environmental performance or digital orientation.

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