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Sustainability Impact of Digital Transformation in E-Commerce Logistics

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ABSTRACT

Purpose: This study investigated the digital transformation in logistics and its effects on sustainability. It provides answers to questions about what digital transformation and related technologies are in logistics, how the transformation altered the operational processes, and which merits have been realized as a result of digital transformation. As part of the fourth industrial revolution, most businesses are digitally transformed. Since commerce is the primary focus of the digital revolution, phrases like "Commerce of the Future" and "E-Commerce" are used interchangeably with this idea.

Methodology: Qualitative research methods and semi-structured interviews were used to elicit information from participants in six (6) e-commerce logistics companies in Nigeria. Seventeen (17) pertinent criteria are identified, of which ten relate to the economic feature of sustainability, two relate to the environmental feature, and the remaining five relate to the social feature.

Findings: From the sustainability dimensions, the economic impacts of digitization outweighed the other two dimensions, even though the evaluation of some criteria by the participants was ambiguous. Digitization of logistics has great merits regarding cost, delivery time, delay, inventory, dependability, and flexibility. Aside from this, it was found that the social effects of digitization, such as better health outcomes and decreasing accident occurrences, have little bearing on society. While the digitalization of logistics may alleviate safety and health issues, it was less accepted because it was perceived as a threat to labor involvement.

Originality/value: The study demonstrated the significant sustainability impact of digital transformation in logistics as it gives birth to e-commerce logistics operations.

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1. Introduction

Commerce is the physical form of buying and selling goods and services for money. Electronic commerce (e-commerce) is an activity that involves the purchasing and trading of goods and services over the Internet with different computerized forms of digital gadgets such as smartphones, computers, and Internet-Enabled Devices (IEDs) which connect the buyer and the seller, and enable the display of products (Andrew, 2021).

Logistics is the process of planning and executing the efficient transportation and storage of physical goods from the point of origin to the point of consumption to meet customer requirements in a timely, cost-effective manner. From the storage of raw materials to the ultimate distribution of the finished product, logistics is concerned with both physical and informational movements (Zacharia, Sanders, & Nix, 2011). According to (Adeniran, Akinsehinwa, & Olorunfemi, 2022) and (Li, 2014), it is defined as the physical and information flows, storage, and distribution of raw materials to the doorstep of consumers.

E-commerce logistics, or electronic logistics (e-logistics), is the process of planning and executing the efficient transportation and storage of physical goods that have been ordered and paid for through digital means from the point of origin to the point of consumption to meet customer requirements in a timely, cost-effective manner. This facilitates the connection between customers and sellers over the Internet rather than dealing with the distribution or actual transportation of goods (Diana, Pirra, & Woodcock, 2020).

A type of commerce called logistics allows investing in the components of logistics and carrying out logistical activities. It is used in many different contexts, including supply chain management, demand planning, warehousing, production, procurement, product flow, marketing, and inventory control. It is also used in information and control processing, fleet management, packaging and unitization, efficiency, customer service, delivery processes, and third-party logistics services. This implies that e-commerce is a form of logistics.

Information and communication technologies (ICTs) are the driving force behind electronic commerce logistics (e-commerce logistics). This type of logistics has the potential to improve trade efficiency globally and integrate emerging nations into a global economy (United-Nations-Conference-on-Trade-and-Development, 1999). Because of this, (Chowdhury, 2003) noticed that e-commerce logistics had significantly increased in developed nations during the last twenty years, while (Adeniran et al., 2022) observed that this had also been witnessed in developing nations over the last ten years. E-commerce logistics is the management of the physical flows of an organization that sells goods via an online platform.

The fourth industrial revolution has sped up the digitalization process and changed corporate content. It has also made the environment and market structure more dynamic. (Almeida & Correia, 2016) state that during the digitization process, corporate processes have developed quickly and progressively, current practices and procedures embarked upon have improved, and the market has grown significantly in size and scope. The main goal of Industry 4.0 is to apply the Internet of Things (IoTs) and services using emerging information technologies (Nahr *et al*., 2021; Sadeghi *et al*., 2021) (Ghahremani Nahr, Nozari, & Sadeghi, 2021) (Mohammad Ebrahim Sadeghi & Jafari, 2021). This will allow business and engineering processes to be closely integrated, allowing for flexible, cost-effective, and environmentally friendly business operations that are always of high quality (Ghahremani-Nahr & Nozari, 2021) (S. Wang, Wan, Li, & Zhang, 2016).

To accomplish the desired goals towards "Smart Business," such as absolute transparency in business dealings in real-time, small sizes, multiple product variants, connected processes, and decentralized, autonomous management, digital transformation nonetheless primarily focuses on business, such as commerce. Smart business dynamics cannot be implemented unless the associated logistical operations are likewise smart (Kagermann, 2015) (Adebambo & Toyin, 2011). To achieve a dependable and sustainable transport and product supply, digitization is a crucial tool (Obaid, 2022) (PWC, 2016a). The broad use of intelligent and networked digital systems and applications (such as mobile, cloud, sensors, data analytics, machine learning, blockchain, and IoT) and the improvement of horizontal and vertical supply chain partner integration provide a clearer perspective on logistics.

Artificial intelligence in digital marketing plays a continuous role in data-based decisions because deep learning can predict user behavior from the beginning to the end of the purchase path (Uver, 2023). Business analytics and artificial intelligence help to unlock new business opportunities for growth, efficiency, and innovation (Chiani & Adibpour, 2023) (Obaid, 2022). The Internet of Things (IoTs) and blockchains have been used for business models in electronic commerce. The choice of e-commerce effectively affects business strategy (Bayanati, 2023).

A new business paradigm is required to move towards connected, seamless, intelligent, efficient, and sustainable digital logistics, commencing with the business activities regarding the supplying of raw materials, components, and parts and ending with the transporting of those supplies and finished goods, which in turn deliver the goods to the customers who are demanding fulfillment (PWC, 2016b). This is expected to lead to a radical shift in the way that business thinking and implementation in logistics are implemented.

Every business and industry engages in activities that release carbon emissions into the atmosphere, which in turn contributes to climate change. They account for about 22 percent of total final energy consumption and about twenty percent of global carbon emissions. This is done through the burning of fossil fuels, releasing chemicals into the atmosphere, reducing the amount of vegetation and forest cover, and expanding development activities, among others (Adeniran, Muraina, & Ngonadi, 2023) (Gebler, Schoot Uiterkamp, & Visser, 2014).

The goal of digitizing the business sector is the attainment of business transformation (the ability to achieve a more resilient, just, and sustainable operation). This is by the World Commission on Environment and Development (WCED, 1987). It was stated by (van Marwyk & Treppte, 2016) that by 2025, digital technology alone has the great potential to reduce emissions connected to logistics by up to ten to twelve percent and decarbonize the global economy. As a result, the sustainable digital logistics ecosystem aims to represent the interdependencies between sustainability and maintain a balance among its economic, social, and environmental aspects. To support sustainable development, it also seeks to reconsider digitally based business models and rework business procedures throughout the supply chain (Evans, 2017) (van Marwyk & Treppte, 2016).

This study aims to investigate the digital transformation in e-commerce logistics operations and its effects on sustainability using six (6) e-commerce logistics companies in Nigeria.

2. Literature Review

The effects of digital transformation on e-commerce logistics in this digital era cannot be overemphasized. Businesses have shown great anxiety over technical acceleration, even though it calls for much more than just technology. A few of the elements that make up the process of digital transformation include improving employee capabilities, altering organizational structures and

management approaches, empowering leaders, taking cultural differences and values into account, addressing business strategy and process-related issues, considering customer journeys and experiences, and leveraging technology to drive and facilitate the organization's business models.

Nonetheless, until technology adoption results in modifications to the organization's overall strategy, system, culture, and mindset and eventually propels the development of the whole business model, it cannot be considered a transformative process on its own (Gezgin, Huang, Samal, & Silva, 2023) (Mohamad Ebrahim Sadeghi, Khodabakhsh, Ganjipoor, Kazemipoor, & Nozari, 2021). To be competitive, organizations need to adapt to evolving technologies by refining and improving their present procedures. Businesses have benefited from and even seen an improvement in performance from the digital transition, although (Agyabeng-Mensah, Ahenkorah, Afum, Dacosta, & Tian, 2020) assert that there is still a great deal to learn about the ideas of digitization, digitalization, and digital transformation. Traditional forms of logistics may be transformed into digital and intelligent logistics operations through digital transformation, which links all logistics components, operations, and activities, including ordering, payment, handling, warehousing, packaging, and transportation.

A wide range of topics are covered by the framework for digital transformation, including partnerships, businesses, and the adoption of new technologies, processes, and business models. Different stakeholders, such as governments, suppliers, financial institutions, retailers, and customers, must not be left out. Businesses are exploring technological opportunities to sustain and have a competitive advantage over their competitors (Perera, Perera, & Wijesinghe, 2013).

2.1. Business Consciousness on Environmental Practices

Businesses are now more concerned about the environment than they have ever been. As noted by (Chen & Kitsis, 2017) (Zhu, Sarkis, & Lai, 2013) (Chu, Yang, Lee, & Park, 2017), most industries have already recognized and valued the concept of environmental management. In the past, businesses only made an effort to refrain from activities that directly broke environmental laws to avoid penalties and prohibitions, such as waste management and satisfying emission requirements (Bag, Pretorius, Gupta, & Dwivedi, 2021) (Fang & Zhang, 2018). Nonetheless, regulations have been tightened by authorities throughout time (Liu et al., 2012), and people's understanding of various environmental degradation and protection issues has been a major motivator for everyone to pay attention to the environment (Tseng, Islam, Karia, Fauzi, & Afrin, 2019).

According to (Afum et al., 2020), many firms' environmental performance strategies and related activities have undergone considerable changes as a result of managerial comprehension of the environmental concept and its realized merits. According to (Geng, Mansouri, & Aktas, 2017), awareness fosters an understanding that all supply chain processes (internal and external) have the potential to hurt the social or environmental spectrum. As a result, genuine initiatives are needed at every stage of the supply chain, both internal and external. According to (J. Wang, Zhang, & Goh, 2018), proactive thinking results in value creation through promising environmental interactions.

According to (Mohanty & Prakash, 2014), to address environmental challenges, there is a growing need for green supply chain management. The application of green idea within any firm results in both social and financial gain because businesses now take cognizance of green operation as a competitive advantage rather than merely a way to improve their corporate image (YU, GOLPÎRA, & KHAN, 2018). Despite being aware of the numerous financial merits, some of the supply chain managers still do not prioritize environmental issues, according to (Abu Seman et al., 2019) (Adeniran

et al., 2022). The fact that many of the merits of eco-friendly innovation are invisible is the reason why green supply chain management is not given as much attention.

2.2. Social Media

Any online platform that actively works to promote real-time audience participation and communication is referred to as social media. Social media's primary characteristic is that it promotes users' active engagement. While Facebook and other social media sites welcome user interaction in the form of comments and likes, the vast majority of social media sites limit users to reading the information that other people have submitted.

Moreover, creating a personal page is crucial to promoting involvement and communication. Second, interacting with people online, whether they are strangers with similar interests or friends, requires communication (Bigliardi, Filippelli, Petroni, & Tagliente, 2022). Daily social media is the term used to describe the growing trend of using social networking sites to promote businesses or causes. When customers visit social networking sites, they want businesses to provide material that they would want to share with their friends and followers. This is the ultimate purpose of social media.

Because of this, the growing ubiquity of Google, Facebook, Twitter, and YouTube emphasizes the necessity of a social networking strategy, which is a method that is being used more and more in social media marketing. Online material that is shared increases a business's visibility in search results and attracts new clients. It is indisputable that these digital channels may be utilized as a dependable way to communicate, engage with customers, establish connections, and promptly address problems. You may create a social media plan by describing the kinds of content you will create and share on each network (Jabeur, Nait-Sidi-Moh, & Zeadally, 2018).

Small and medium-sized enterprises (SMEs) use social media extensively for communication as well as the advertising of their goods and services. Social media's immediateness enables companies to maintain an open and honest communication channel with their online clientele. Consumers can converse with one another and exchange opinions on the products and services they have bought. Most companies that use social media do so to keep an eye on discussions about their competitors, products, and industry (Ding, Liu, & Zheng, 2016).

2.3. Digitization in Logistics

The use of new technology to improve relationships between manufacturers and customers as well as logistical businesses is known as digitization. Many of the earlier studies have examined the implications of digitization on logistics and supply chains. Businesses involved in logistics and supply chain environments use hardware, software, and global communication networks to better achieve operations. In terms of a theoretical framework, digitization is still in its infancy, in comparison. The advancement of information and communication technology is essential to digitalization (Agrawal & Narain, 2023).

An organization experiences organizational and cultural change as a result of digitalization, which is a reaction to market demands. From this vantage point, a logistics company's conventional operations may be fully redesigned into a system where social, organizational, and human activities are all perfectly interconnected. To propel management transformation towards Industry 4.0, the linkage inside the logistics operation requires collaboration across numerous technologies, including sensors, cloud processing, cyber-physical practices, and high-performance computing (Mohammad Ebrahim Sadeghi & Jafari, 2021) (Muñoz-Villamizar, Charris, Quintero-Araujo, & Santos, 2019).

Until recently, a lot of organizations thought of technology only as a way to share information and enhance communication to promote productivity. However, a lot of logistics companies now prioritize digital transformation as a result of the COVID-19 epidemic. These companies have discovered the hard way (as a result of the COVID-19 pandemic) that technology ought to be seen as an instrument for preventative management. Analytical services and information technology play a major role in digital transformation, and contemporary technologies enable prompt and innovative situational responses. The idea that digital transformation may improve operational and financial performance, customer centricity, and multi-supplier partnership relationships within logistics organizations is becoming more and more supported by data (Holmström, Holweg, Lawson, Pil, & Wagner, 2019).

Strategic decision-making may be substantially boosted by better data acquired through digital procurement's greater access to creative suppliers, cooperative platforms, innovation labs, sophisticated analytics, increased processing capacity, and visualization tools. This emphasizes how crucial it is to use digital procurement to get better data for making strategic decisions. Because digital transformation accelerates the delivery of monitored logistical assistance and support to individuals in need, due diligence is crucial to logistics management (Effing & Spil, 2016).

To create a digital representation that can be electronically processed or stored, an analog signal must first be captured and then converted into digital form, a process known as digitization (Ornig, 2016). Information and communication are now accessible to everyone, wherever, at any time, through any device, and any kind of access as a result of digitization. A growing amount of recorded information has gone digital due to the increased usage of computer technology. In 1993, just 3% of all recorded information worldwide was saved digitally; by 2007, that number had risen to 94% (Stuermer, Abu-Tayeh, & Myrach, 2017).

A network, as an entire supply chain or a single logistics process, becomes more digitally connected; the better data and transactions are captured and processed, the more intelligent systems are added, and the more these systems communicate with one another through connections. According to (van Marwyk & Treppte, 2016), Digitalization partially or disrupts logistical operations, but it also has the potential to provide intrinsic value for the sector and society at large. To provide customers with the most efficient and transparent service delivery, building a logistics network with digital systems would enable businesses to step up their competition and offer a new level of resiliency and responsiveness (PWC, 2016b). This is because analytic technology, such as hyper-connectivity, supercomputing, or big data, obtains large-scale logistics data, and applying complex algorithms to this data helps businesses find areas where they can increase profit margins.

A white paper published by the World Economic Forum suggests that by 2025, logistics Digitalization may generate $1.5 trillion in value (van Marwyk & Treppte, 2016). Technology, process, organization, and knowledge are the four main enablers that form the foundation of the digital logistics ecosystem (Stuermer et al., 2017). Digital logistics strategies must succeed by combining technology and apps with sound knowledge management throughout businesses and business processes. There are six characteristics of digitalizing logistics: connectedness, cooperation, integration, adaptiveness, cognitive improvement, and autonomous control.

The complete integration of a broad range of digital systems, including data analytics, cloud, mobile, augmented reality, the Internet of Things, sensors, and three-dimensional (3D) printing, into logistics processes enhances the advantages of:

1) Spare parts management;

2) Logistics visibility;

3) Smart procurement and warehousing, advanced analytics, and

4) Autonomous logistics (PWC, 2016b).

The following six attributes of a digital logistics design, along with the technology at hand, offer major advantages for organizing, scheduling, and managing freight and logistics operations:

a) Autonomous decision-making;

b) Making a whole customer experience possible with augmented reality technologies such as wearable computing;

c) Cloud computing-based information collection that is location- and device-independent;

d) Reducing failures in complex processes;

e) Improved automation via interaction between humans and machines;

f) Low management complexity through decentralized approaches;

g) Efficiency and visibility for logistics centers and transportation networks;

h) Software architecture and an open, intelligent user interface that facilitates collaboration both vertically and horizontally;

i) Complete transparency across the supply chain;

j) Real-time operations; and

k) Increased potential for optimization using big data analytics.

Furthermore, by using "what-if scenario analysis" to model the system, these digital systems enable businesses to foresee potential hazards and adjust logistical procedures in real time in response to supply chain interruptions. The entire planning, organizing, sourcing, manufacturing, controlling, delivering, and returning processes will be digitalized completely; this will save lead times and enable swift workflows. Understanding how digitization affects logistics from the standpoint of the social, environmental, and economic facets of sustainability can provide insight into the logistics ecosystem that is digitally driven toward sustainability. The following should be reflected in the sustainability features:

1) The social feature of digitized logistics*:* Digitized logistics makes it easier for people and communities to obtain basic requirements, meet those needs securely, and promote high-quality lifestyles without jeopardizing intergenerational and intergenerational fairness.

2) Environmental feature of digitized logistics: Digitalized logistics employs technology that reuses and recycles its components, minimizes the use of non-renewable energy sources, and minimizes greenhouse gas emissions, pollution, and waste.

3) The economic feature of digitized logistics: Digitalized logistics enable the usage of cost-effective systems that function effectively, provide joint solutions and a variety of transport mode options, and boost the local economy may be used.

The comprehensive descriptions and features of digitization in logistics are:

2.3.1. Cooperation

(van Marwyk & Treppte, 2016) state that cooperative action through digitization, such as the shared storage and transportation system, will boost the logistics sector's reliability and efficiency. Due to this, there are particular requirements for data integration, information sharing across organizations, and design support for virtual logistics clusters. To use logistical services outside their operational boundaries, virtual service providers form strategic alliances with other businesses and partners, allowing them to share their physical infrastructure (Chang & Hadzic, 2006). This is predominant in the airline business.

An example of this would be the utilization of a digitally linked cross-border logistics hub to aggregate storage and transportation resources over a vast, geographically dispersed region of operation. The core of a digital operational model is the use of digital capabilities across information technology, data and performance management, procedures, governance, and processes. It permits the necessary degrees of process standardization and integration (Raab, 2011).

2.3.2. Connectivity

In this case, the term "technology" refers to the ability of a resource to accept a connection from another resource or to act as an interface to other digital resources on the network (Mackenzie Owen, 2007). Vertical integration, made possible by digitization through connectivity from supplier to customer and horizontal integration between competitors and other business partners throughout the supply chain, may both preserve end-to-end visibility. Businesses can balance supply and demand for underutilized products and assets because of technologies like machine-to-machine (M2M), hyper-connectivity, supercomputing, and real-time big data analytics. Social media, smartphones, and cloud computing may dematerialize whole sectors or even individual items. By using self-regulating mechanisms to prevent mistakes and unforeseen disruptions, the logistics system is made more intelligent and productive. Furthermore, according to (Lacy & Rutqvist, 2016), 3D printing opens up possibilities for producing inputs that are eternally recyclable or biodegradable, such as coco-pallet.

2.3.3. Adaptiveness

A system that is open, dynamic, and adaptable is referred to as digitization. It is defined by the fact that its constituent parts and their relationships may change over time and that external events can have an impact on it. According to (Mackenzie Owen, 2007), the networked digital resource system is both flexible enough to be altered by an external actor, such as a graphical user interface, and self-adaptive, meaning it adjusts itself in response to perceived changes in the environment, such as user input or modifications to the internal structure of the system. Smart bins or containers are examples of what can be configured to use various sensors for tracking and tracing.

2.3.4. Integration

In the context of the digital economy, this refers to a system's capacity to connect, integrate, monetize, and share any type of data, device, system, or process in close to real-time. The integration of information technology and logistics systems is the process of functionally and physically linking many software programs and computer systems to function as a coherent, well-coordinated whole. The interconnections between the logistical subsystems give it extra value. Integrations of three kinds are feasible:

i. Value networks attained through horizontal integration;

ii. Networked logistics systems and vertical integration; and

iii. End-to-end digital integration of logistics throughout the value chain (S. Wang et al., 2016).

The application of Software as a Service (SaaS) and other digital service platforms that enable communication between back-end systems of organizations enable the seamless integration of cloud, mobile, and other application programming interface (API) digital ecosystems with traditional data centers and enterprise services. Using this system logic, digitally enabled global logistics platforms are built up to link all users (shippers, logistics providers, etc.) and maintain a real-time working environment. These platforms combine the demands of several shippers, streamlining the whole logistics planning process and recommending the best modes of transportation depending on the location of the warehouse and the intended delivery point (van Marwyk & Treppte, 2016).

2.3.5. Autonomous control

Decentralized, independent decision-making is made possible by digitization. Being autonomous means acting on one's initiative and without external supervision. Transvoyant is one example of a machine-learning technology that aids with predictive analytics. Sensors, satellites, radar, video cameras, and smartphones may all be used to gather and analyze many real-time events that occur every day (Manent, 2017). An algorithm is used in logistics systems to monitor the flow of goods in real time while estimating the arrival time and accounting for port traffic, natural catastrophes, and weather. Adidas is employing analytics to enable customers to purchase products in several ways, such as online and in-store, and have them delivered in any way, including at home, in a store, or at a pick-up location. This is known as an omnichannel approach.

2.3.6. Cognition

Logistics activities are changing significantly as a result of the introduction of technologies such as artificial intelligence (AI), robots, and drones for managing the domestic and international movement of goods. The performance of the logistics business, both now and in the future, is greatly influenced by some technologies and applications, including autonomous mobile robots, unmanned aerial vehicles, unmanned ground vehicles, and self-driving automobiles. Additionally, autonomous vehicles have a greater potential to improve road safety and reduce accidents (Trubia, Giuffrè, Canale, & Severino, 2017). Automakers, including Daimler, Volvo, and Scania, are exploring self-driving trucks; Google's driverless automobile is making significant strides (Chandra, 2016); and Uber completed the first autonomous delivery operation.

For large deliveries, Amazon is constructing flying warehouse blimps and investigating the feasibility of using drone technology to carry tiny goods. Nonetheless, this technology has attained "a level of maturity" in warehouse operations. Additionally, picking processes using autonomous forklifts are increasing productivity in warehouse logistics. In contrast, drones will generate $20 billion in business impact from faster and less expensive last-mile delivery services in both rural and urban areas (van Marwyk & Treppte, 2016). Autonomous trucks are expected to save $30 billion in fuel, maintenance, employee, and insurance costs.

2.4. Logistics Management Capabilities

The practice of seeking growth that meets current demands while protecting the capacity of future generations to satisfy their own is known as sustainable development. The ability of an organization to satisfy the demands of its clients, advocacy groups, shareholders, staff, local communities, and so on without jeopardizing that ability in the future is known as corporate sustainability. The underlying principle of this concept is the interconnectedness and interdependence of businesses, society, and the environment. Consequently, logistics businesses are not allowed to prioritize their shareholders' short-term earnings over their long-term sustainability (Chacón Vargas & Moreno Mantilla, 2014). To meet

the difficulties posed by many stakeholders, businesses must go beyond just economics and incorporate sustainability into the process of formulating their strategy (Beske & Seuring, 2014).

The sustainability dimensions should reflect the following:

i. Economic sustainability: This is a form of reasonably priced system that boosts the local economy, works well, offers cooperative solutions, and offers a range of travel possibilities.

ii. Environmental sustainability: Since they recycle and repurpose their resources, they consume less non-renewable energy and generate less waste, pollution, and greenhouse gases.

iii. Social sustainability: This entails guaranteeing the safe fulfillment of people's and communities' basic access needs in a way that encourages intergenerational fairness and healthy lifestyles (Kayikci, 2019).

3. Methodology

This study adopts a case study qualitative research method using a Delphi panel to examine six e-commerce logistics businesses in Nigeria. A case study methodological design was used to assess how digitalization in logistics affects sustainability, with an emphasis on comprehending the dynamics of a particular situation (Yin, 2014). The purposeful sampling technique was used, and the sampling itself was incidental. This is appropriate for this study due to the time limitation for each participant to be interviewed. Data was gathered from 1st to 20th December 2023.

The Delphi panel was used in this study, as it utilizes two iterative questionnaires to elicit information from experts in e-commerce logistics and allows them to revise their responses based on group feedback. Each of the e-commerce logistics experts in a respective organization that were purposefully sampled formed a group. Thus, the number of groups formed is the number of organizations (six groups equals six organizations). Three senior representatives were purposefully selected from each organization based on their high positions.

The first iteration, targeted at respondents, enabled them to supply information based on their raw experience, while the second iteration was to perfect the information they supplied after deliberating with their peers in the organization. This method was indeed adopted to ensure anonymity and iterative feedback (Alldredge, Newaskar, & Ungerman, 2015).

To prepare them for rapid adaptation in the face of shifting customer behavior, particularly with the development of digital, the case study is conducted inside six e-commerce logistics firms in Nigeria. To determine the qualitative effects of digitization on the economy, environment, and society, such as the three sustainability aspects of logistics as described by the (WCED, 1987), such as a descriptive sustainability evaluation.

A preset set of criteria is used to base the evaluation; the implications of these criteria are identified and discussed. Only a qualitative approach can be taken to the social indicators because digitalization technologies are still in their infancy. On the other hand, energy, expenses, and carbon emissions may be used to quantify the other economic and environmental variables. Nevertheless, because it was difficult to get representative data for this study, (Monnet, 2011) noted that all sustainability parameters are usually assessed subjectively. Due to the lack of a comprehensive sustainability assessment of the digitalization of logistics, as well as the fact that prior research on sustainability dimensions has mostly concentrated on transportation as opposed to logistics, the criteria were extracted from the literature using a systematic review.

As indicated in Table 1, a feature has been deemed suitable to serve as criteria if it has a sustainability effect connected to digitalization in logistics. Seventeen (17) pertinent criteria are identified in due course; of these, ten (out of seventeen) relate to the economic feature of sustainability, two to the environmental feature, and the remaining five to the social feature. The aforementioned digitization features are taken into consideration while making decisions based on the listed factors to assess the impact of digitization from a logistical viewpoint.

Table 1. Standards by which the sustainability implications of the digitalization of logistics

Sustainability Features	Sustainability Criteria	Description	Source
Economy	Logistics cost [A1]	Modifications to the cost-saving measures for transportation, storage, carrying inventory, and administration.	(Monnet, 2011) (Dougados, Ghioldi, Van Doesburg, & Subrahmanyam, 2013) (Gebler et al., 2014) (PWC, 2016b) (van Marwyk & Treppte, 2016)
	Delivery time [A2]	Modifications to delivery improvements, cycle time, and lead time.	(Monnet, 2011) (Dougados et al., 2013) (Gebler et al., 2014) (PWC, 2016b) (Raab, 2011) (van Marwyk & Treppte, 2016)
	Transport delay [A3]	Modifications to the amount of delayed shipment.	(Monnet, 2011) (PWC, 2016b) (van Marwyk & Treppte, 2016)
	Inventory reduction [A4]	Modifications to inventory volume.	(Dougados et al., 2013)
	Loss or damage to goods [A5]	Adjustments to the quantity of lost or damaged products as a result of mishaps, theft, and damage.	(Monnet, 2011)
	Frequency of service [A6]	Regular interval adjustments to the utilization rate (load factor).	(Dougados et al., 2013) (PWC, 2016b)
	Accuracy of forecast [A7]	Modifications to demand uncertainties.	(Dougados et al., 2013) (PWC, 2016b)
	Reliability of service [A8]	Alterations to the level of logistics quality concerning shipping, stock, and storage, such as flawless orders and on-time delivery.	(Monnet, 2011) (Dougados et al., 2013) (Gebler et al., 2014) (PWC, 2016b) (van Marwyk & Treppte, 2016)
	Volumes of freight [A9]	Modifications to the total transported freight volume	(Monnet, 2011)
	Use of applications[A10]	Applications that make sense for digitizing logistical procedures.	(Gebler et al., 2014) (PWC, 2016b) (van Marwyk & Treppte, 2016)
Environment	Resource efficiency [B1]	The use of automobiles and transportation infrastructure depletes non-renewable resources.	(Gebler et al., 2014) (Monnet, 2011) (PWC, 2016a)
	Land use impact [B2]	Changes to the amount of land used for transportation and the pace of land loss.	(Monnet, 2011)
Society	Development merits [C1]	Implications of technology for sustainable development.	(Gebler et al., 2014) (PWC, 2016b)
	Health [C2]	Effects on health brought on by logistical digitization.	(Gebler et al., 2014) (PWC, 2016b)
	Safety [C3]	Changes to the number of fatalities and disabilities resulting from accidents.	(Monnet, 2011) (PWC, 2016b) (van Marwyk & Treppte, 2016)
	Labor patterns [C4]	Modifications to labor intensity, employment schemes, and work types.	(Gebler et al., 2014) (Monnet, 2011) (PWC, 2016a)
	Acceptance [C5]	Acceptability of digital applications in the society, economy, and market.	(Gebler et al., 2014) (PWC, 2016b)

4. Findings

4.1. Major Findings

Data was elicited from eighteen (18) participants across six e-logistics companies in Nigeria. Two participants were directors/ chief executive officers (CEOs), seven were co-founders (CFOs), and nine were chief technical officers (CTOs). The companies were established between 2013 and 2019.

Following the identification of a set of standards for the sustainability impact of digital transformation in e-commerce logistics, e-commerce logistics firms were investigated. Six e-commerce logistics organizations were chosen for this study because, in addition to collaborating in logistical activities, they invest in digital transformation and implement the newest digital systems and applications in their business operations.

To complete the table, questions were asked from experts in each of the logistics firms regarding the subject. *How do you evaluate the sustainability impact of digital transformation in logistics processes and operations for the characteristics of logistics*? Please rate each of the following statements on a five-point scale based on your experience with the firm: 𝟎𝟎𝟎, *high impact* 𝟎𝟎, *moderate impact,* 𝟎 *less, no impact*.

4.2. Discussion

The findings demonstrated the significant sustainability impacts of digital systems and application usage on logistics operations within e-commerce logistics firms. Notably, the economic implications of digitization's sustainability impact outweighed the other dimensions, even though participant evaluation of some criteria's impacts was ambiguous. Digitization of logistics has a tremendous deal of promise when it comes to concerns related to cost, delivery time, delay, inventory, dependability, and flexibility. This agrees with the study of (Samadi-Parviznejad, 2022) that digital systems and application usage enhance the creation and collection of significant information. With this, businesses have the opportunity to comprehend the behavior of consumers and design functional and smart marketing strategies.

In addition, research revealed that the social effects of digitization, such as better health outcomes and a lower incidence of accidents, have largely had little effect. The digitalization of logistics might alleviate safety and health issues, but it was first perceived as a threat to labor patterns, which reduced full digitization. This agrees with the findings of (Ghahremani-Nahr & Nozari, 2021), which revealed that competition is as fierce as in e-commerce. It also corroborates the findings of (Obaid, 2022) and (Kian, 2021), which explained that competition is not limited to just online and physical stores but the entire internet space is competing with online retailers. Artificial intelligence platforms are key components for achieving e-commerce success. This finding corroborates the findings of (Mortaji & Shateri, 2023) (Ghahremani Nahr et al., 2021) (Mohammad Ebrahim Sadeghi & Jafari, 2021).

Reducing land use was the primary effect of digitalization on the environment. As a result, entrepreneurs, regulators, and policymakers should work together to maximize value without compromising land use, thereby factoring in the contributions of a green environment. It is anticipated that digitization will produce significantly more value for society than for the economy (van Marwyk & Treppte, 2016).

Table 2. Sustainability implications of the digitalization of logistics across the six selected e-logistics firms in Nigeria

Sustainability Features	Sustainability Criteria	Digitization Characteristics					
		Cooperation	Connectedness	Adaptiveness	Integration	Autonomous Control	Cognitive Improvement
Economy	[A1]	🅞🅞	🅞🅞🅞	🅞🅞	🅞🅞	🅞	🅞
	[A2]	🅞🅞🅞	🅞🅞	🅞🅞	🅞🅞	🅞🅞🅞	🅞🅞
	[A3]	🅞🅞🅞	🅞🅞	-	🅞🅞🅞	🅞🅞	🅞
	[A4]	🅞🅞	🅞🅞	🅞	🅞🅞🅞	🅞🅞	🅞🅞
	[A5]	🅞🅞🅞	🅞	n/a	🅞🅞🅞	🅞	🅞🅞
	[A6]	🅞🅞	🅞🅞	🅞	🅞	🅞🅞	🅞🅞
	[A7]	🅞🅞🅞	🅞🅞🅞	🅞🅞	🅞	🅞🅞	🅞🅞
	[A8]	🅞🅞🅞					🅞🅞
	[A9]	🅞	🅞	-	🅞🅞	🅞	🅞🅞
	[A10]	🅞🅞	🅞🅞	🅞🅞🅞	🅞🅞	🅞🅞🅞	🅞
Environment	[B1]	🅞🅞🅞	🅞🅞	🅞	🅞🅞	🅞🅞	🅞🅞
	[B2]	🅞🅞🅞	🅞🅞🅞	🅞🅞	🅞🅞🅞	🅞🅞	🅞🅞
Society	[C1]	🅞	🅞🅞	🅞	🅞	🅞🅞	🅞🅞
	[C2]	🅞🅞	🅞	🅞🅞	🅞🅞	🅞🅞	🅞🅞
	[C3]	🅞🅞	🅞🅞	🅞🅞	🅞🅞	🅞🅞	🅞🅞
	[C4]	🅞	🅞	🅞	🅞	-	-
	[C5]	🅞	🅞	🅞	🅞🅞	🅞	🅞

Denotations: 🅞🅞🅞*; High impact* 🅞🅞*; Moderate impact* 🅞*; Less or no impact*

5. Conclusion

With the present business dynamics that are technologically driven, digital transformation is indeed inevitable for any business to sustain itself and continue into the unforeseeable future. This is most evident in e-commerce logistics businesses as they will be able to generate big data, which enhances forecasting accuracy for effective and efficient planning and decision-making. This study provided answers to questions about the effect of digital transformation and related technologies in logistics, how the usage of digitization altered the operational processes, and which merits have been realized as a result of digitization.

There are many discussions on the impact of digitization on transport sustainability, but few on logistics. Consequently, this study offers a fresh method for comprehending the consequences of sustainability from a logistical standpoint. Since digitization in logistics is still emerging, it has not yet attained maturity. As a result, the implications of sustainability may be enhanced and modified as digitalization in logistics matures.

The study demonstrated the significant sustainability impact of using digital systems and applications in logistics within e-commerce logistics companies. From the sustainability dimensions, the economic impacts of digitization outweighed the other two dimensions, even though the evaluation of some criteria by the participants was ambiguous. Digitization of logistics has great merits regarding cost, delivery time, delay, inventory, dependability, and flexibility. Aside from this, it was found that the social effects of digitization, such as better health outcomes and decreasing accident occurrences, have little bearing on society. While the digitalization of logistics may alleviate safety and health issues, it was less accepted because it was perceived as a threat to the involvement of labor.

Reducing land use was the primary effect of digitalization on the environment. As a result, entrepreneurs, regulators, and policymakers will need to work together to maximize value for both business and wider society without compromising land use, thereby factoring in the contributions of a green environment. Finally, it was predicted in this study digitization will benefit society more than the economy.

It is pertinent to note that despite the positives brought by digital transformation on businesses, it can easily be influenced by government investment decisions, programs, and policies. Hence, there is a need for the government to be actively involved in transforming businesses digitally by creating an enabling environment through the provision of digital infrastructures and formulating implementable sound policies and programs that will digitally drive businesses. It is recommended that further studies should explore the quantitative analysis, and expand the geographical scope to capture more e-logistics firms.

Abbreviations

CEO: Chief Executive Officer

CFO: Co-Founders

CTO: Chief Technical Officers

ECL: Electronic commerce logistics

ICTs: Information and Communication Technologies

IEDs: Internet-Enabled Devices

Industry 4.0: Fourth Industrial Revolution

IoT: Internet of Things

WCED: World Commission on Environment and Development

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Conflicts of Interest

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