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Reimagining the Last-Mile Distribution System Under Internet of Things Diffusion

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ABSTRACT

The last-mile sector, as a catalyst of the supply chain logistics network, epitomises an integral part of electronic commerce (e-commerce) in mitigating fluctuating consumer demands during and post-COVID-19 pandemic. Reliable, responsive and agile customer goods deliveries have become the focal point in diffusing innovative last-mile delivery-based technologies. This study, therefore, aimed to examine the viability of last-mile distribution, underpinned by the advent of emerging technologies such as the Internet of Things (IoT). The objectives are to establish the extent of applied IoTs within the last-mile distribution industry system. Furthermore, to examine the influence of organisational strategy on the use of IoTs in the last-mile logistics industry. The theoretical framework underpinning the study is the Technology Organisation Environment (TOE) framework and complexity adaptive theory, employed within an exploratory research design. The quantitative analysis of the impact of IoTs on the cost and quality of 179 purposively and snowball-sampled stratified last-mile distribution companies in the Durban region, using univariate and bivariate methods. The main findings suggest that the integration of IoTs in the last-mile logistics industry has the potential to optimise routing, eliminate in-process collisions, enhance cost efficiency, and enable organisations to exercise agile operations, responding to quasi-real-time visibility of inventory levels in stores, in transit, and warehouses.

Keywords: Last-mile distribution, IoTs, logistics, TOE.
JEL: R12, O33.

INTRODUCTION

The impact of the Internet of Things (IoT) on the cost and quality of service experience for last-mile logistics is a critical challenge for the final phase of supply chain distribution. With the relentless growth of e-commerce and the increasing demand for efficient and reliable delivery services, understanding how IoT affects last-mile logistics is increasingly becoming important both for companies and consumers alike. The integration of IoT technologies, such as Global Positioning System (GPS) tracking, Radio Frequency Identification (RFID) systems, and real-time data analytics, optimises their distribution processes, reduces costs, improves quality, and enhances the overall customer experience. Additionally, the meticulous implementation of IoT in last-mile distribution systems in Durban has the propensity to improve efficiency and effectiveness. The study focuses on the last-mile distribution systems and the role of IoTs as a focal technology to establish innovative technological impact, organisational challenges and applicability to the business environment. The TOE framework was chosen to frame the technology, organisation, and environment in this research study, while using a quantitative approach (univariate and bivariate methods) to analyse the data. The study provides a brief background, research objective, theoretical framework, research methodology, data analysis, and recommendations, along with managerial implications.

Background of the Study

Last-mile delivery is a critical component of the supply chain, but it faces numerous challenges, exacerbated by the complexities of the COVID-19 era (Srinivas & Marathe, 2021). Complexity epitomises the degree to which the individual views the innovation as being difficult to understand and use (Rogers, 2010). While it is the most crucial link, it is also the least effective logistics distribution system to complement the scalability of e-commerce economic activities. Efforts to eliminate challenges and enhance transportation quality have led to a focus on consumer-driven logistics, cost reduction, and innovative solutions, such as micro-hubs and crowd delivery (Weber & Badenhorst-Weiss, 2018). Yang et al. (2022) suggest that in recent years, the global demand for efficient and reliable last-mile distribution systems has been on the rise, driven by the rapid growth of e-commerce and the need to reach geographically dispersed customers. The multiplier growth effect compounded and exponentially impacted technological innovation solutions and last-mile distribution logistics, driven by the increasing demand for home and satellite hub/store deliveries. The multiplier effect describes the impact that changes in the last-mile logistics supply chain have on economic activity, and it has a trickle-down effect on Industry 4.0 concepts, such as IoT in e-commerce businesses, and impacts last-mile distribution. Ignat & Chankov (2020) define e-commerce as the selling and buying of items using the internet or an online platform, with a substantial increase in interest over the recent past, particularly for domestic e-commerce (such as household consumables, clothing, food items, and electronics). Mangiaracina, Perego, Seghezzi, & Tumino (2019) suggest that online shopping platforms offer an endless array of options for customers, allowing them to search and purchase products at any time from any location. It is a crucial step in the online shopping process, as it is the only interaction between the customer and the courier service, which can be viewed as a representative of the company (Jiang, Li, Zang, Dong, Lianf, & Mladenovic, 2021). South Africa, as a rapidly developing nation with a thriving digital economy, is not immune to the challenges associated with last-mile logistics (Ajayi & Laseinde, 2023). The last-mile logistics companies in Durban serve as the focal sample frame to establish the magnitude of challenges to adopting IoT and further examine the influence of an organisation's strategy for using IoT in the last-mile South African logistics industry. The research paper focuses on last-mile logistics innovations using IoT, electronic fulfilment and distribution in omni-channel retailing (Melacini, Perotti, Rasini & Tappia, 2018), last-mile logistics models, and vehicle-based alternatives for last-mile distribution in urban freight (Oliveira, Bandeira, Goes, Gonçalves & D'Agosto, 2017; Zhong, 2020).

Research Problem and Objectives

The key challenges for the last-mile distribution system align with the increased complexity of demand for speedy delivery, reliability, agility in adapting, and responsiveness in delivering quality logistics services. The complexity of implementing IoT in last-mile distribution systems in South Africa highlights the elusive goal of improved efficiency and effectiveness. Efficiency depends on multiple factors, such as consumer density and time windows to reach informal and formal settlements, congestion related to poor town planning and mini-bus taxis, fragmentation of deliveries, and shipment size and homogeneity, which are the most expensive, inefficient, and ineffective parts of the supply chain. The middle mile, with its complexities and scale, has a significant impact on the overall efficiency of the supply chain. It is also the most expensive stage in terms of labour costs, logistics software, and surcharges for failed deliveries. The primary challenge is to identify potential cost savings, quality improvements, and enhancements to customer satisfaction and overall performance in the last-mile distribution (LMD) sector. Last-mile service companies face the challenge of providing cost-effectiveness and superior quality of service, despite increased demand for deliveries, in order to flourish in the online market and improve their performance.

The IoT integration enables seamless communication, proactive and informed decision-making, and reduced delivery delays. The research study seeks to establish the potential of the IoT to overcome challenges and improve efficiency in last-mile distribution. By leveraging IoT technologies and real-time data analytics, organisations can optimise their distribution processes, reduce costs, improve quality, and enhance the overall customer experience. This study, therefore, aimed to examine the viability of last-mile distribution underpinned by emerging 4IR technologies, such as the Internet of Things. The technologies of Industry 4.0 impact the connection between products, customers, production, and service companies, and the IoT fosters a collaborative alliance of numerous complementary technologies working together to bridge the gap between the digital and physical worlds (Shee & Miah, 2021).

The design and operation of first-mile, mid-mile, and last-mile supply chain logistics involve a multitude of challenges, including facility location, routing, scheduling, design of loading unit buildings and packaging processes, budgeting, warehousing, and assignment or queuing. The objectives are to determine the extent of IoT application within the last-mile distribution industry system. Furthermore, to examine the influence of organisational strategy on the use of IoT in the last-mile logistics industry. Leveraging IoT's capabilities can enhance efficiency, visibility, and responsiveness in deliveries, leading to satisfied customers and reduced operational costs. By addressing South Africa's unique logistics challenges, this research lays the groundwork for more efficient and sustainable distribution operations, enabling businesses to deliver goods with improved quality and cost-effectiveness.

FRAMEWORK AND LITERATURE

The IoT is not a single technology, but rather a collaborative alliance of numerous complementary technologies that work together to bridge the gap between the digital and physical worlds (Balaji & Roy, 2017; de Vass, Shee, & Miah, 2021). The phrase "Internet of Things" was first used in 1999 by the Massachusetts Institute of Technology's (MIT) Auto-ID Centre for Supply Chain Management to describe a method of tracking items via the Internet using radio-frequency identification (RFID) linking to an Electronic Product Code (EPC) serving as a unique identifier for each item (Birkel & Hartmann 2019 and Tu 2018). Zhang, Zhou, Cao & Wu (2020) add that the term Internet of Things (IoT) was first used in 1999 in the radio frequency device (RFID) arena. Singh & Srivastava (2019) define the IoT as a system that offers interconnectedness to the Internet and is characterised by predetermined procedures. It employs equipment that senses information to transfer and communicate data, providing smart recognition and offering management for evaluating, tracking, and locating. Furthermore, technologies enable better integration of different transport modes and tariffs. Merging different modes of transport into one service to suit the mobility needs of individual customers is now an established business model, known as mobility-as-a-service (MaaS). IoT has gained traction through mobile devices, as well as embedded and universal communication, to entrench functionality, quasi-real-time accessibility, and efficient operationality in the last-mile logistical distribution system. It has also spread due to the software-as-a-service modality, facilitated by cloud computing and the use of data analytics. The IoT therefore, can be used to advance and connect smart containers, pallets, packaging, packing materials, vehicles, shelves, forklifts, infrastructure, ports, terminals and others with the use of Radio Frequency Identification (RFID), Global Positioning System (GPS) and Wireless Sensor Network (WSN) systems in the last-mile distribution of goods in supply chain logistics. Logistics and supply chain design focus on the design of various supply chain aspects, such as fulfilment, distribution, hub-and-spoke systems, last-mile logistics models (Winkenbach & Janjevic, 2018), and logistics challenges related to the distribution system (Macioszek, 2018; Zhang & Huang, 2020).

Last-Mile Logistics

The efficiency of the courier company and the condition in which the packages are delivered determine the overall quality of the service, despite all subsequent processes administered by an automated system designed to achieve optimal production (Tumino, Mangiaracina, Perego & Seghezzi 2019).

The ***first mile stage*** deals with individual producers or manufacturers, the last mile focuses on individual customers, and the middle mile concerns itself with bulk transportation. First-mile delivery is the initial stage of shipping, during which goods leave the production facility or supplier warehouse (Macioszek, 2018; Winkenbach & Janjevic, 2018). For retailers, first-mile delivery is the transport of goods from the supplier warehouse to the retailer’s store while in e-commerce, the first mile might be the journey of the goods from the retailer to the delivery courier who delivers to the customer’s home, workplace or another pick-up point (Woody, Craig, Vaishnav, Lewis & Keoleian, 2022; Mbhele, 2023).

The ***middle-mile stage*** also involves addressing various legal and geopolitical considerations, which may include customs clearances in the case of international shipping or compliance with regional laws and regulations for transportation and logistics (Macioszek, 2018; Mbhele, 2023). The last mile signifies the final leg of the logistics journey, bringing goods from the local distribution centre to the consumer's doorstep (Jamous, Kerbache & Omari, 2022; Kafile & Mbhele, 2023), and it remains the final touchpoint where the supply chain interacts directly with the customer (Jing & Hu, 2023). The Durban last-mile delivery involves land-based methods, such as cars, vans, bikes, or lorries, and still restricts the use of drone air transport. The coordinated miles (first, middle, and last) heavily rely on emerging technologies for development and deployment to enhance the efficiency of last-mile delivery, making it easier for consumers to receive their desired products with speed and precision. The main hurdles in the first mile stage involve ensuring the accurate picking of goods, efficient packaging, and practical information systems for tracking and documentation (Zhang & Huang, 2020; Jing & Hu, 2023). Middle-mile delivery, in most cases, refers to the transfer of goods from a distribution centre to a fulfilment facility. Despite the significant increase in online shopping, e-commerce businesses and other retailers still rely on brick-and-mortar sorting facilities to process and deliver goods to the right customers (Macioszek, 2018; Mbhele, 2023).

Last-mile delivery is defined as the final segment of a delivery process, encompassing a series of activities and processes necessary for the delivery from the last transit point to the final drop-off point of the delivery chain (Lindner, 2011; Melacini, Perotti, Rasini, & Tappia, 2018). The courier logistics deliveries resonate with direct doorstep customer delivery (Oliveira, Bandeira, Goes, Gonçalves & D'Agosto, 2017); however, there is an emergence of self-collection delivery as an alternative to home delivery to enhance the customer experience. The fragmented socio-economic system, characterised by informal settlements ("Umjonodolo" in the Zulu language) and a rural, segregated ecosystem, hinders seamless delivery due to chronic hijacking, dilapidated road infrastructure, and cluster housing design. Self-collection delivery involves the provision of a network of service points where operators pool and deliver their consignees' parcels, and consignees pay, collect or return their parcels (Piplani & Saraswat, 2012; McKinnon & Tallam, 2003), such as service points could be stationary (collection at locker points or convenience stores), mobile (collection at locker-fitted vehicles), satellite fulfilment centre such as one at University of KwaZulu Natal – Takealot centre and Mr Price, attended (collection aided by a service attendant and retailer store such Pep and petrol station such as Engen garage), or unattended (collection aided by fully-automated systems) (McKinnon & Tallam, 2003).

Urban last-mile design: Coria, Rodríguez, and Prieto (2020) explain that up to 80% of companies manage their logistics in-house rather than outsourcing to an external logistics provider. Due to this, the effectiveness of urban transport systems is decreased as the load capacity from multiple customers is reduced. This highlights the potential in this sector, although the volume of mini-bus taxis and Uberisation system on the road brings movement complexities in the urban Durban region. The Urban Logistics Opportunities-Last-Mile Innovation report compiled by Wang, Yuen, Wong and Teo (2020) predicted that in 2025, the cost associated with logistics globally would increase by up to 10.6 trillion. Last-mile deliveries will account for up to 40 per cent, while the total percentage of expenses accounted for by logistics will be 70 per cent. There are many factors to consider regarding urban supplies and the associated costs of the social aspect. One of the greatest advantages of using the last mile is the convenience of door-to-door delivery and decreased delivery times. Customers receive orders from the convenience of their workplace or residence, with quick turnaround times and often same-day or next-day delivery (Woody, Craig, Vaishnav, Lewis, & Keoleian, 2022). However, Rajendran & Wahab (2022) suggest that it is a costly service, with the expected date of delivery not guaranteed, and complications associated with locating the delivery address or the possibility of the recipient not being available to receive the delivery. It operates using a digital key, which is allocated to customers on a one-time basis, to open the deposit box and place the parcel. The delivery details are then sent to the customers. Jamous, Kerbache, and Omari (2022) indicate that the package can also be placed in a designated location within the house, such as a garage, where pickup is arranged. Peppel, Ringbeck, and Spinler (2022) discuss the concept of sharing economics as an alternative to addressing the challenges faced by the last-mile, such as crowdsourcing. Delivery services include society and the associated resources, and Swamy, & Kota, (2020) share the following number of devices predicted to be connected to the internet by 2025.

Source: Swamy & Kota (2020).

The above-estimated number of devices predicted to be connected to the internet by 2025 is expected to generate approximately 80 Zettabytes of data (Swamy & Kota, 2020). Last-mile logistics companies offer services utilising custom applications, which combine the creative alliance of cost and quality of service experience for last-mile logistics mobile services, known as MaaS. This is achieved through the use of numerous complementary technologies and the internet's interconnectedness, which enables the functioning of such services. The delivery service provides quick and direct delivery to customers, as the number of connected devices in the last-mile logistics industry continues to increase, further compounded by the number of devices per person. Gupta, Yadav, Kusi-Sarpong, Khan, & Sharma (2022) suggest that providing efficient service to ensure success is based on research into complementary technologies and a company conducting its own studies to anticipate potential stakeholders, possible retailers, client markets, as well as other last-mile service providers.

THEORETICAL FRAMEWORK

A theoretical framework is a comprehensive review of existing theories that serves as a roadmap for developing the arguments the researcher will use, identifying key concepts, evaluating and explaining relevant theories, and demonstrating how current research fits into existing research (Vinz, 2022). A complex adaptive system (CAS) theory is nonlinear and exhibits various internal and external elements; it becomes apparent that it should be approached from a systemic perspective to underpin the Technology-Organisation-Environment (TOE) framework. CAS theory is defined as the dynamic ability of systems to adapt and evolve in response to changes in their environment (Choi, 2001; Day, 2014; Nair & Reed-Tsochas, 2019; Schiffling et al., 2020). The need to understand how firms in such complex networks coevolve with one another to determine appropriate responses to external stimuli and the exponential growth of online customer demands.

IoT, with a creative alliance of numerous complementary technologies working together to bridge the gap between the digital and physical worlds (Shee & Miah, 2021), mitigates complexity. Digital coevolution enables more efficient, flexible, and customer-focused supply chain solutions by leveraging key technologies, such as smart logistics and warehousing, and advanced information analysis to create in-sync first-mile, mid-mile, and last-mile logistics systems and large-scale networks. This will help businesses gain competitive advantages from their complex interactions with technology, the environment, and organisations (Yaroson, Breen, Hou, and Sowter, 2021). The theory supports the Technology-Organisation-Environment framework in providing explanations for how order and last-mile value chains exist within complex and non-linear logistical distribution systems, which are influenced by geo-design and ecosystems (Holland, 2006; Parast, 2020; Schiffling et al., 2020). In its ability to learn from experience, a CAS evolves based not only on the dynamic interactions within its organisational context but also on the interactions between the environmental and technological contexts.

Therefore, CAS underpins the TOE framework that outlines the process of innovation (Tornatzky & Fleischer, 1990). It notes three features of an enterprise that influence the implementation of innovation, efficiency, and responsiveness in the last-mile logistic system: technology, organisation, and environmental context. The technology context refers to the internal and external technologies applicable to the organisation, and the organisational context refers to the illustrative characteristics of the firm, including resources and methods of communication among employees and supply chain collaborators in the transportation system (Curtis & Payne, 2008). The environmental context comprises the market elements, competitors, and the regulatory environment (Tornatzky & Fleischer, 1990). The framework aims to assess the strategic influence of IoT on last-mile logistics in terms of effectiveness, efficiency, and responsiveness.

Technological last-mile Context

Technology context is frequently embedded in machines to facilitate the operation of procedures, often even without detailed or specific knowledge of their workings, to render tasks less costly and more efficient (Mbhele, 2023), while improving the effective performance of last-mile distribution with the application of recent technology (Kuang, 2018; Alhaimer, 2021). According to Madlamini (2018), technology encompasses the accumulation of methods, techniques, processes, and skills in the distribution and delivery of goods or services to achieve business plans and objectives for first-mile and last-mile logistics. Rodrigues, Ruivo & Oliveira (2021) and Alhaimer (2021) assert that relative advantage plays a crucial role in the adoption of IoT in last-mile logistics, enabling the continuous improvement of operations cycles, logistics cycles, and process cycles. The relative advantages of applying Internet of Things technologies in the last-mile distribution industry in South Africa are benefits such as collaboration, competitiveness, effectiveness and efficiency. Abed (2020) found that relative advantage has a significant influence on the adoption of technology. Chatterjee (2021) notes that compatibility aligns with the advantages of IoT technologies. It focuses on the rate of technological innovation, the propensity for adoption by organisations, and the dependence on the current standard of operations, as well as the organisation's beliefs, values, previous experiences, and needs. These relative advantages enable manufacturers to establish online stores, present their retail outlets online, mitigate delays while simultaneously maximising improvements, and effectively meet customer demands.

Organisational last-mile Context

The Organisational context focuses on the characteristics and resources of an organisation that reflect features such as the firm's structure, readiness, climate, interactions between employees, and intra-firm communication processes (Qalati et al., 2020). Chatterjee et al. (2021) also note that the organisational context relates to many other factors, such as the company's leadership in formalising and developing new systems, its management, the availability of financial and other resources, and the leader's attitude towards innovation. Finally, Sunardi, Hamidah, Buchadadi, and Purwana (2022) and Qalati et al. (2020) have emphasised the importance of a firm's size, employee knowledge, and organisational development in the adoption of innovation, as well as its incremental or radical nature. As a result, their overall performance is influenced by reactions to internal and external challenges. Bai, Dallasega, Orzes & Sarkis (2020); Alabi, White & Beloff (2020) and Alabi at el, 2020) make the argument that organisational readiness as the availability of resources to apply and maintain technology innovations within an organisation, for implementation of subsequent changes, and coverage of ongoing expenses during usage require organisational procedures, structure and top management to support the adoption of new IoT technologies like e-commerce and cloud computing. Chatterjee, Rana, Dwivedi, & Baabdullah (2021) argue that the knowledge of IoT technologies is another important factor contributing to the adoption and application of technology by organisations. Rodrigues (2021) and Farrow (2022) note that various studies have found firm size to be a significant determinant of new IoT adoption. However, Alabi, White, & Beloff (2020) have a different view of the above statement, indicating that SMEs are better suited for adopting new ICT due to their flexibility and agile nature than big organisations.

Environmental last-mile context

The environmental context describes the company's sector of activity, its competitors, customers, and suppliers (Alhaimer, 2021). Chege and Wang (2020) argue that it is analysed through the size and structure of the industry, the macroeconomic context, and the legislative measures. The adoption of change within an organisation is thus determined by its economic and institutional environment, market uncertainty and competitive pressure (Chege & Wang, 2020). Chan, Fang, & Li (2019) argue that competitive pressure often leads organisations to adopt innovations that competitors and partners have already adopted. Although government support provides a conducive environment, Bai, Dallasega, Orzes, & Sarkis (2020) stress that government support is a determinant of innovative technology adoption in the environmental context, especially in SMEs' support structures for adopting new and advanced technologies. Pan, Froese, Liu, Hu, & Ye (2021) agree with the above statement by reporting that private organisations, government, and different agencies, such as venture capital and business angels, are working towards the adoption of IoT technologies by SMEs by providing these businesses with infrastructure and IT support to influence the adoption and use of innovative technologies. "Furthermore, competitive pressure, as the pressure that comes in from the industry's competitors, places top managers in a position to be concerned about being perceived, amongst their peers, as lagging behind their competitors or suffering financial losses" (Bhatiasevi & Naglis, 2020, p. 91). The aforementioned authors further explain that in industries with high competition, it is crucial to be ahead in adopting new technologies. The TOE framework illustrates that for innovation to be adopted, there must be a formal or informal linkage with other value chain partners to improve efficiency, effectiveness, responsiveness, agility and competitiveness in the last-mile distribution for the logistics industry.

RESEARCH METHODOLOGY

Research approach and design

The research methodology "refers to the theory of how research should be undertaken" (Saunders et al., 2020). An exploratory study is a valuable means of asking open-ended questions to discover what is happening and gain insights about a topic of interest for inferring (Sekaran, 2020; Creswell, 2021; Saunders et al., 2020). This study employs an exploratory quantitative research approach to frame the technological, organisational, and environmental aspects of IoTs in the last-mile distribution system in the Durban region. This section provides an understanding of how ontology corresponds to epistemology and, in turn, corresponds to the methodology to which the study subscribed and the tools that were employed. It is therefore vital that researchers emphasise the study's perspective in terms of the different philosophical perspectives, such as ontology (what constitutes knowledge), epistemology (how we know it), and axiology (what values are involved in it). With this epistemological stance, positivists seek to establish relationships between constructs, generally by comparing groups or responses using quantitative methodologies, such as experiments and surveys. The quantitative analysis of the impact of IoT on the cost and quality of LMD companies helped to evaluate the potential benefits of integrating IoT technologies in improving last-mile distribution in South Africa. A survey questionnaire was designed to collect data from last-mile distribution companies within the Durban region of South Africa, including logistics managers, delivery personnel, and administrators. The survey was designed to gather information on the challenges faced, the potential benefits of IoT adoption, and the critical factors influencing cost and quality. The survey was administered electronically using online survey platforms, ensuring anonymity and confidentiality of the participants. The collected data were then analysed using appropriate statistical techniques.

In establishing the extent of applied IoTs within the last-mile distribution industry system, the positivist philosophy was adopted to focus on four critical elements: precision, generalisability, reliability and replicability. The researchers resonate with an enquiry embedded in a series of logical, organised steps that lead to a "claim of knowledge based on objectivity, standardisation, deductive reasoning and control enforced in the process of research" (Martini, 2017, p. 89). The influence of organisational strategy on the use of IoT in the last mile of the South African logistics industry aims to analyse the technological impact of IoT on LMD companies, as well as the environmental challenges and benefits of integrating IoT technologies to improve last-mile distribution in South Africa.

Population, sampling and sample size

The population in the context of this research was selected using purposive and snowballing sampling (nonprobability) and included last-mile distribution companies in Durban. The practical reason for excluding other LMD companies in South Africa is that Durban is one of the three biggest cities in South Africa with an effective and sustainable logistics sector; therefore, this population was a good representation of the entire country. According to Sekaran & Bougie (2016, p.203), sampling is "the process of selecting a sufficient number of the right elements from the population so that a study of the sample and an understanding of its properties allow for generalisation to the population elements". Based on the formula for sample size with a 5% margin of error, the sample size for this study was 210, yielding a response rate of 179. Stratified random sampling (probability sampling) was used to ascertain the position held by each participant in the group, thus ensuring that the sample was representative. According to Cooper & Schindler (2014) and Saunders et al. (2020), stratified random sampling is a process of selecting and modifying a sample to include subjects or elements from each of the segments, based on several attributes. It specifies the traits that the sample should include the logistics managers, delivery personnel, and administrators.

Research Findings, Analysis and Discussion

Based on the study's aim, this section presents the results and analysis of the collected data, along with a discussion of the findings. Understanding the benefits of IoT in LMD can facilitate the assessment of the returns on investment (ROI) and value proposition for implementing IoT solutions. By gathering data on the positive outcomes, its impact can be quantified in various aspects, such as cost savings, productivity gains, error reduction, quality improvements, enhanced customer satisfaction, and a competitive advantage. The research findings will, therefore, contribute to the development of industry best practices and guidelines. These insights can be shared with industry professionals, policymakers, and stakeholders to facilitate informed decision-making, encourage collaboration, and accelerate the adoption of IoT solutions in the LMD sector.

The descriptive statistics on organisational context indicate that IoT technologies are currently in use within organisations to evaluate their impact on the cost and quality aspects of organisational operations. The descriptive analysis revealed that smart IoT technology influenced operations, tracked vehicles, and monitored and managed transportation logistics, which can have direct implications on cost efficiency, route optimisation, overall quality of service, and expanded delivery routes optimisation. This expansion might signify potential cost savings through efficient route planning and quality of service, as it can impact delivery times and customer satisfaction at the order fulfilment point. This suggests potential improvements in inventory management and order processing efficiency, which can positively impact both cost control and the accuracy and timeliness of deliveries, ultimately affecting quality. Furthermore, IoT was linked to improved deliveries encompassing various aspects, including on-time deliveries, reduced errors, and enhanced customer experiences, thereby promoting both cost-effectiveness and quality enhancement within the LMD industry. The IoT has the potential to address the critical challenges of the LMD ecosystem, such as reverse logistics and defect management, while packaging and labelling, as well as sensory features, would be beneficial for the order-fulfilment management model. The results of IoT further benefit an organisation with sensors for asset tracking and management, product safety, and improved transportation conditions through wireless technologies for communication and data transfer from sensors, respectively.

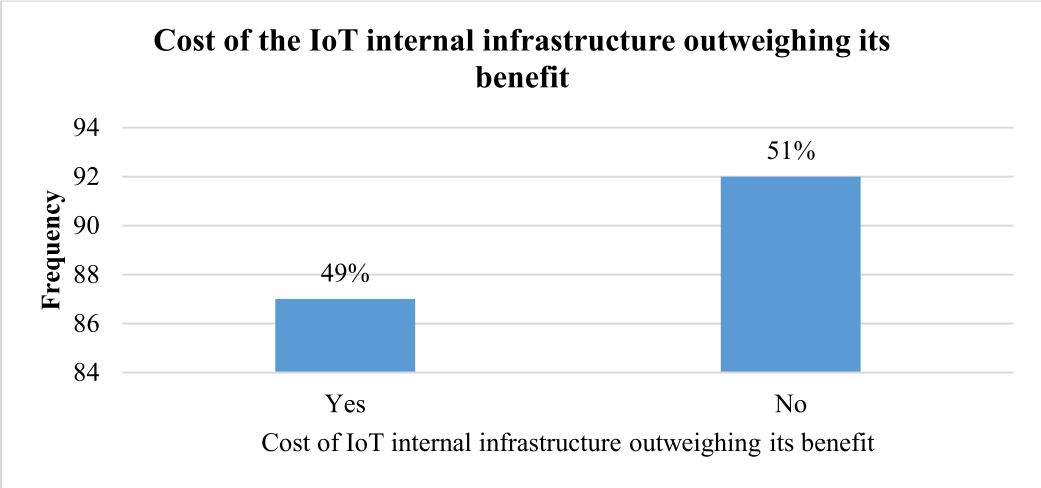

Figure 1: Cost of the IoT internal infrastructure outweighs its benefits

Furthermore, the descriptive statistics revealed that 51% of the respondents disagreed that the cost of IoT internal infrastructure outweighs its benefits, while 49% concurred with this statement.

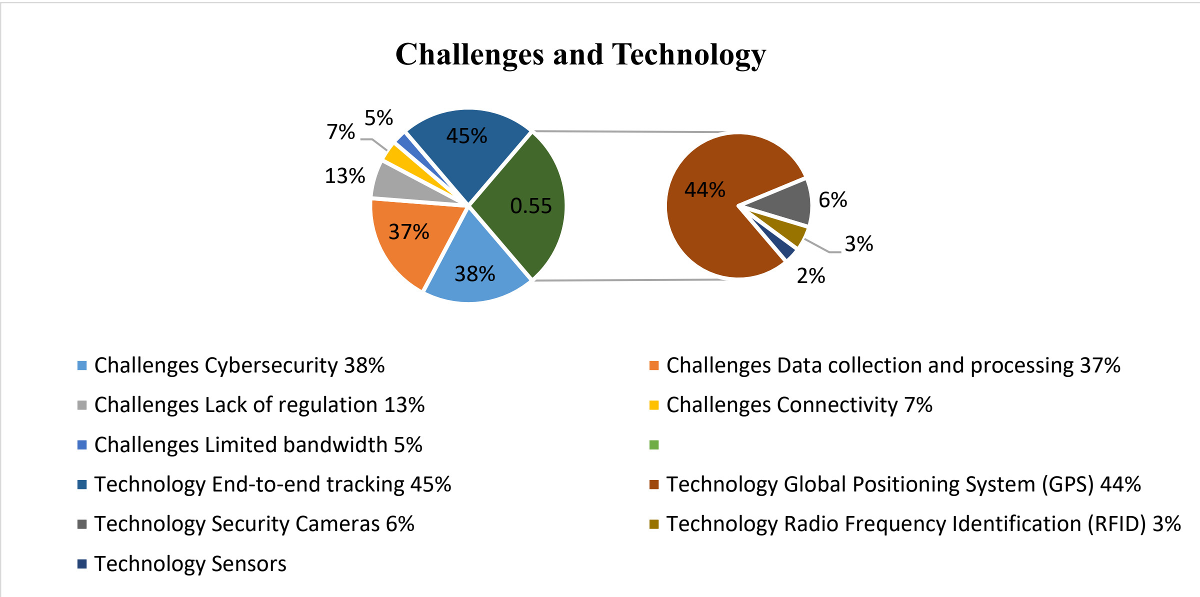

Figure 2: Challenges and commonly used IoT technologies

Figure 4 revealed that the challenges of the IoT in the LMD industry, with most respondents (38%) identifying cybersecurity, followed by 37% who opted for data collection and processing. Moreover, 13% pointed to a lack of regulation, 7% cited connectivity issues, and 5% mentioned limited bandwidth. To further explore the integration of IoT within the LMD sector, respondents were asked about the prevailing IoT technologies employed within their organisation. The findings showed that the technologies that are currently most used, 45% (n=178), were linked to End-to-End tracking, revealing its prominent role. Furthermore, 44% of these cases were credited to the Global Positioning System (GPS), underscoring its wide adoption. In contrast, only 2% (n=9) of the cases were associated with sensors, indicating their limited usage, and 6% were attributed to security cameras, while 3% were attributed to Radio Frequency Identification (RFID). These results hold significant implications for both cost-effectiveness and quality enhancement within the LMD industry.

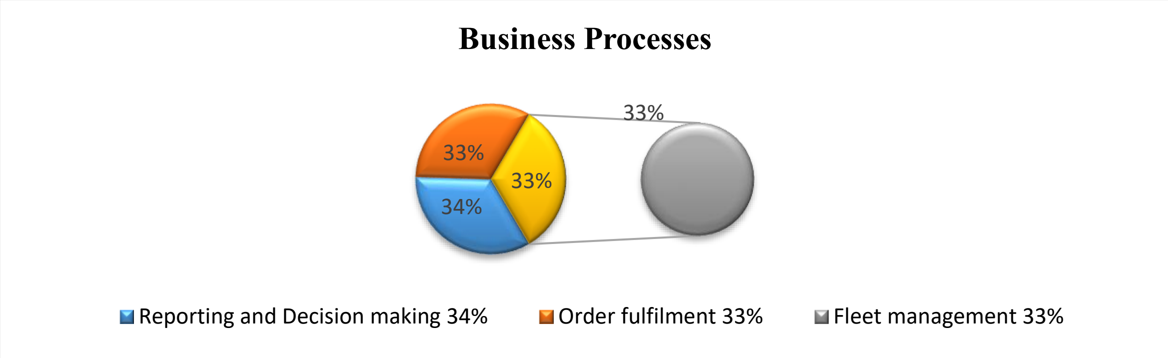

Figure 3: Business processes that are affected by IoT

Furthermore, respondents were asked to identify the business processes affected by IoT within their organisation. Figure 5 revealed that business processes affected by IoT (34%) were attributed to reporting and decision-making. This indicates that IoT technology plays a crucial role in enhancing data-driven decision-making processes. Additionally, 33% were linked to fleet management, revealing how IoT contributes to cost optimisation in this area as IoT devices can provide real-time tracking and monitoring of vehicles, leading to more efficient route planning, reduced fuel consumption, and maintenance cost savings, all of which positively impact the organisation's overall cost structure. Finally, 33% of the cases were associated with order fulfilment, underscoring the importance of IoT in streamlining supply chain operations. Improved visibility and tracking of inventory and orders can result in faster and more accurate order processing. These results highlight that IoT significantly affects both cost and quality in various business processes, emphasising its potential to drive efficiency, reduce expenses, and enhance decision-making within the organisation.

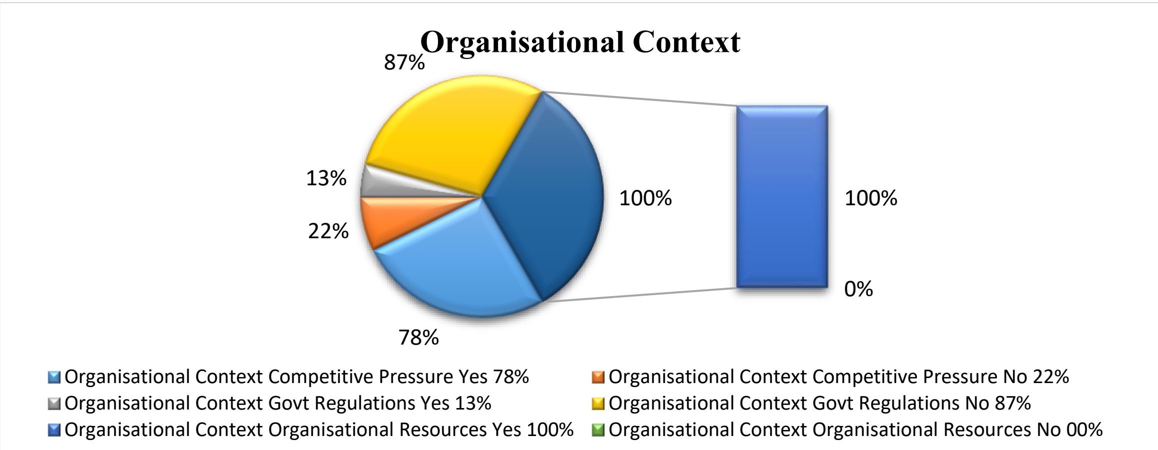

Figure 4: IoT implementation

The section focuses on IoT's implementation in an organisational context (Competitive industry pressures have influenced organisations' decision to use IoT technologies; some governmental regulations or initiatives influence organisational decisions to adopt innovative technologies; and Organisational resources influence the decision to make use of IoT technologies in organisations). Further, the descriptive statistics of this study revealed that most of the respondents (n=140; 78%) believe that the competitive industry pressures have influenced their organisation's decision to use IoT technologies, while about N=39 (22%) do not think that the competitive industry pressures have influenced their organisation's decision to use IoT technologies. Further, most of the study respondents (N=156; 87%) reported that there are no governmental regulations or initiatives that influence organisational decisions to adopt innovative technologies. Approximately 23 respondents (13%) stated that some governmental regulations or initiatives influence organisational decisions to adopt innovative technologies. Lastly, the statistical analysis of the study data showed that all respondents believe organisational resources, such as expertise, firm size, and financial resources, influence the decision to utilise IoT technologies in their organisation.

Table 1: Organisations' use of IoT Chi-Square tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	58.385[a]	18	<.001
Likelihood Ratio	60.708	18	<.001
Linear-by-Linear Association	.239	1	.625
N of Valid Cases	179		
a. 16 cells (57.1%) have expected count less than 5. The minimum expected count is .04.			

H_{O1}: Existing organisational resources do not significantly influence the adoption and use of IoT technologies in the last-mile distribution sector.
H_{A1}: Existing organisational resources significantly influence the adoption and use of IoT technologies in the last-mile distribution sector. The cross-tabulation analysis showed that all respondents agreed that organisational resources influence the decision to utilise IoT technologies. However, one could infer that existing organisational resources do not significantly influence the adoption and use of IoT technologies in the last-mile distribution sector, as most of the respondents stated that the use of IoT in their organisation is under moderate and somewhat basic conditions.

Table 2: Degree of the benefit Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	55.784[a]	12	<.001
Likelihood Ratio	51.908	12	<.001
Linear-by-Linear Association	33.251	1	<.001
N of Valid Cases	179		
a. 14 cells (70.0%) have expected count less than 5. The minimum expected count is .02.			

The study explored the degree of the benefits.
H_{O2}: The expectation of benefits of IoT technologies doesn't significantly influence their adoption and use in the last-mile distribution sector.
H_{A2}: The expectation of benefits of IoT technologies does significantly influence their adoption and use in the last-mile distribution sector.
The researchers conducted a chi-square and cross-tabulation on the benefits of IoT and its adoption in the last-mile distribution sector. The results showed statistical significance between the impact of IoT and its use in the last-mile distribution sector (p-value = 0.001). This implies that the expectation of benefits from IoT technologies significantly influences their adoption and use in the last-mile distribution sector.

Table 3: Policies to Accommodate IoT Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	33.241[a]	6	<.001
Likelihood Ratio	33.936	6	<.001
Linear-by-Linear Association	17.708	1	<.001
N of Valid Cases	179		
a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is .58.			

H_{O3}: Organisational structure doesn't significantly influence the adoption and use of IoT technologies in the last-mile distribution sector.
H_{A3}: Organisational structure significantly influences the adoption and use of IoT technologies in the last-mile distribution sector.
The research conducted a cross-tabulation and chi-square analysis to examine the relationship between organisational policies for accommodating IoT and organisations' use of IoT. The analysis showed a statistical significance between organisational policies to accommodate IoT and the use of IoT (p-value < 0.001). This implies

that organisational policies to accommodate IoT influence the organisational use of IoT technologies in the last-mile distribution sector.

DISCUSSION OF FINDINGS

This section contains the summary of the research findings, recommendations, implications for the study and the study's concluding remarks. The study found a strong correlation between cost and quality efficiency in LMD businesses using IoT technology. Key factors influencing cost and quality include monitoring tools for fuel, lighting, and temperature management in fleets and facilities, reducing unexpected downtime, and providing prompt alerts (Ali, Poksoy, Torg˘u & Kaur, 2021; Ghadge, Kara, Moradlou & Goswami, 2020; and Choudhury, Behl, Sheorey & Pal, 2021). These findings align with previous research on Logistics 4.0 initiatives, which benefit the economy by reducing logistical expenses, increasing productivity, and enhancing customer satisfaction (Alabi, White, & Beloff, 2020; Nguyen & Petersen, 2017; Rodrigues, 2021; Armenia, Casalino, Gnan, & Flamini, 2021). The study also revealed that the LMD sector has not fully embraced IoT technologies due to infrastructure, compatibility, organisational culture, and a lack of skilled individuals. IoT presents opportunities for retailers to optimise ordering, minimise wastage, and enhance the customer experience. In last-mile logistics, IoT technologies have a positive impact on responsiveness and performance, with elements such as security cameras, IoT-enabled vehicles, sensors, RFID, and GPS enhancing productivity and supply chain visibility. Embracing IoT can enable seamless customer experiences for both physical and online retailers. As the e-commerce industry undergoes a digital revolution, businesses should adapt to succeed today and prepare for the future. These findings have implications for various stakeholders, including logistics service providers, retailers, technology service providers, policy makers and investors. The findings of this study also support those of other existing studies (Ghadge, Kara, Moradlou, & Goswami, 2020; Choudhury, Behl, Sheorey, & Pal, 2021; Bag, Gupta, & Luo, 2020).

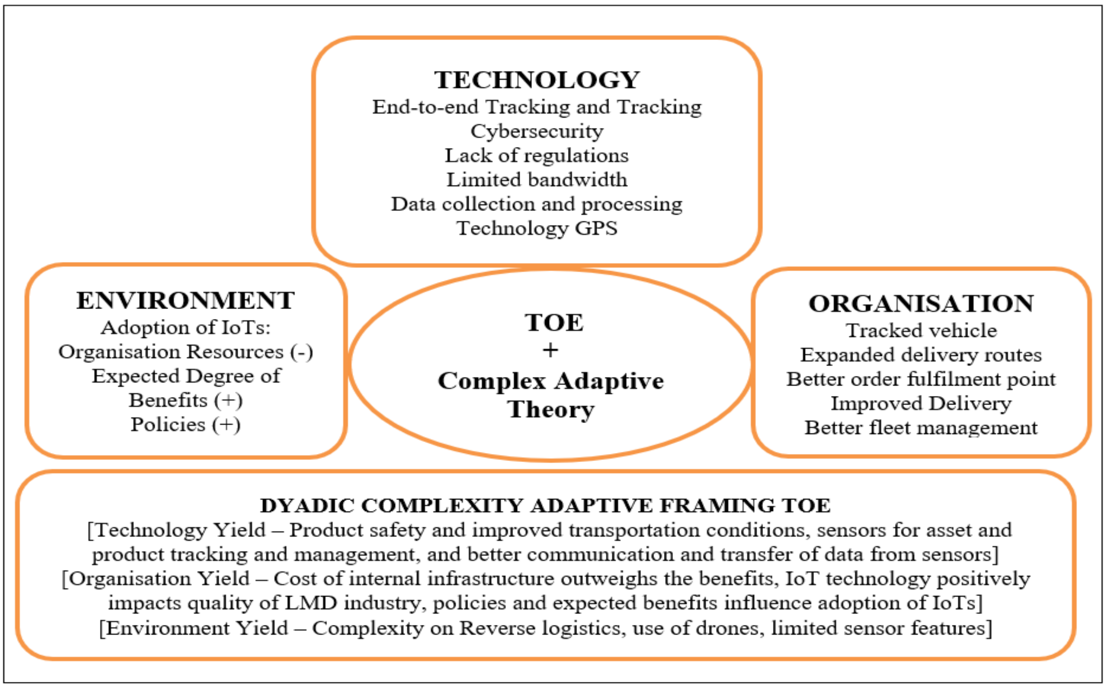

Figure 5: Dyadic Complex Adaptive TOE

Source: Designed by Researchers

The IoT technologies have an impact on the cost and quality aspects of organisational operations. In tracking vehicles, there is a pronounced reliance on IoT for monitoring and managing transportation logistics, which can have direct implications for cost efficiency, route optimisation, and overall quality of service, as well as expanded delivery route optimisation. This expansion signifies potential cost savings through efficient route planning and quality of service, as it can impact delivery times and customer satisfaction. The IoT impacts the order fulfilment point, suggesting potential improvements in inventory management and order processing efficiency, which can positively affect both cost control and the accuracy and timeliness of deliveries, ultimately impacting quality. However, organisational resources do not significantly influence the adoption and use of IoT technologies in the last-mile distribution sector, because the use of IoT in the organisation is under moderate and somewhat basic conditions. The expectation of the benefits of IoT technologies does significantly influence their adoption and use in the last-mile distribution sector. The organisational policies to accommodate IoT influence the organisational use of IoT technologies in the last-mile distribution sector.

Recommendations

The study findings emphasise the need for effective last-mile distribution systems in South Africa, which can be achieved by implementing a combination of technological advancements and strategic approaches. Leveraging mobile technology and digital platforms can enhance real-time tracking, route optimisation, and communication with customers and drivers, streamlining operations and improving efficiency. Currently, the lack of an industry framework and policies promoting the use of advanced technology hinders progress.

Thus, it is recommended that last-mile distribution business managers/owners participate in establishing such a framework to enhance performance benefits. Prioritising IoT development in logistics and supply chain management is crucial for cost-efficient, quality, and sustainable LMD sector. The South African government can encourage the implementation of IoT across various sectors, including logistics, mining, construction, agriculture, healthcare, manufacturing, and technical services, through policy and financial support. This includes investing in cybersecurity by implementing robust security measures and encryption protocols to safeguard sensitive data and IoT devices from potential threats.

The second recommendation is to enhance data collection and processing capabilities, with a focus on data accuracy and real-time analysis, which will enable better decision-making and resource optimisation, ultimately reducing waste and improving both cost and quality efficiency. Furthermore, businesses must invest in IoT-enabled vehicles, sensors, RFID, and GPS to boost productivity, efficiency, and customer satisfaction in the last-mile delivery process. Additionally, the study recommends utilising alternative connectivity solutions, such as edge computing and 5G networks, to mitigate connectivity issues and improve data transmission efficiency.

Lastly, stakeholders across industries should recognise the value of IoT technologies and consider their adoption in day-to-day operations and future planning, as the digital revolution continues to reshape the e-commerce landscape. This proactive approach will enable last-mile logistics businesses to maintain high-quality services while efficiently managing costs, fostering innovation, and sustaining their competitive edge in the face of evolving challenges and opportunities within the sector.

Reliability and Validity of Instruments

Measurement tools are considered to be reliable and valid when they exhibit precise measurement procedures and are characterised as being fit for purpose (Schindler et al., 2008, p. 289). Reliability can be measured using test-retest, split-half reliability, and Cronbach's Alpha for quantitative data (Hair et al., 2007, p. 242). The Cronbach's Alpha (0.945 out of 61 items) is used to test reliability, as the level of homogeneity of the questions in the instrument is scientifically assessed. Validity is measured using content validity, construct validity and criterion validity. Content validity requires consulting a sample of experts to assess the suitability of the items representing a construct on the instrument (Schindler & Cooper, 2008, p. 290). This study was based on established supply chain concepts; therefore, content validity was ensured by consulting with supply chain experts and academics to collect quantitative data. The content validity of the survey instrument was also ensured by reviewing the relevant literature. Additionally, the correspondence with respondents, as well as the survey documents, were reviewed and approved by supply chain experts, including managers, owners, and directors, prior to distribution. The survey was also piloted by sending it to ten stores in the Durban region.

Managerial implications

To survive and succeed, courier companies must embrace cutting-edge technologies that drive business growth. Technology adoption is especially crucial for last-mile logistics companies to effectively reach the market and meet customer demands. Strategies that promote the use of advanced technologies, such as IoT, are essential for success. In South Africa, with reduced consumer spending power, a viable option for SMEs is adopting a low-cost leadership strategy. Maintaining low delivery service costs without compromising quality is crucial for remaining competitive. The adoption of contemporary perspectives in strategy formulation, combined with the leveraging of IoT technologies, holds promise for helping last-mile businesses achieve competitiveness and success.

Policy implications

The study recommends that the South African Government should adopt policies that support the use of technology in logistics companies through strategic management and financial backing. Moreover, allocating resources to address other critical needs, such as infrastructure development (roads, electricity, and internet bandwidth), is vital, as these challenges often hinder progress. To enhance the last-mile sector, the government should prioritise providing managerial and technical skills to the last-mile logistics industry.

Future Research

This study offers valuable insights into IoT's potential to improve last-mile distribution systems in South Africa, with a specific focus on the influence of IoT on the cost and quality of the LMD sector. However, there are opportunities for future research to explore additional dimensions and aspects of IoT integration in last-mile logistics, including risk Management, environmental impact and sustainability, Regulatory and legal implications, customer experience and comparative studies. By addressing these areas of research, scholars would expand the knowledge and understanding of how IoT technologies can transform and optimise last-mile logistics, ultimately leading to more efficient and customer-centric delivery systems.

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