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APPLICATION OF IOT IN LOGISTICS – CHALLENGES; ENABLERS & SUCCESS FACTORS

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Abstract

Logistics has benefitted immensely from the use of Internet of Things (IoT), in realigning the actual value of supply chains to greater visibility, effectiveness and coordinated management of the flow of products. However, this integration is not without its challenges; it has some specific enablers and success factors that are essential to support integration, implementation as well as the operation of the system. This is a review on the use of IoT in logistics to analyses the challenges, the enablers, and the critical success factors involved in the process.

There remains several issues that organizations need to overcome for IoT to improve the function of logistics when adopted. Some of the challenges include; security issues that pertain to data privacy and threats, compatibility problems that come about due to integration of different IoT devices and systems, difficulty in scaling IoT systems due to growth of operation and high initial capital costs that come with establishing IoT systems. Furthermore, the integration of different level of networks and different locations prove to be even more complex for the logistics companies taking up IoT technologies.

To overcome the described challenges and thus to ensure the proper use of IoT in the logistic, some enablers are of special importance. Adaptability to work with cloud computing platforms makes it possible to work with incoming data in real time, thus improving the decision-making process. The application of IT tools for analysis in the stream of big data holds provides an insight for the anticipation of failures and timely problem solving. In addition, the usage of the blockchain improves data protection and traceability of the supply chain activities. The standardization that takes place within the industry also helps to ease compatibility in the use of different IoT solutions.

Keywords: Cyber security; Interoperability; Data handling; expandability; Real time visibility; Prognostic analysis; Business process automation; Information processing; Compatibility with legacy systems; Cross organisational cooperation; spending on technology.

Abstrakt

Sun’iy intellektning logistikada qo'llanilishi ta'minot zanjirlarining ishlash usulida o’rni, misli ko'rilmagan ko'rinish, samaradorlik va tovarlar harakatini boshqarish. Biroq, bu integratsiya o'ziga xos qiyinchiliklar olib keladi va muammosiz amalga oshirish va ishlashni ta'minlash uchun maxsus faollashtiruvchi strategiyalar va muvaffaqiyat omillarini talab qiladi. Ushbu abstrakt logistikada IoTni qo'llash bilan bog'liq murakkabliklarni o'rganadi, duch keladigan asosiy muammolarni, muvaffaqiyatli integratsiyani osonlashtiradigan omillarni va optimal natijalarga olib keladigan muhim omillarini ta'kidlaydi.

Logistikada IoTni joriy qilish, tashkilotlarning o'z imkoniyatlaridan to'liq foydalanish uchun hal qilishlari kerak bo'lgan bir qator muammolarni keltirib chiqaradi. Bu muammolarga ma’lumotlar maxfiyligi va kibertahdidlar bilan bog‘liq xavfsizlik muammolari, turli IoT qurilmalari va tizimlari o‘rtasida o‘zaro ishlash muammolari, operatsiyalar kengayib borishi bilan miqyoslash muammolari va IoT infratuzilmasini joylashtirish uchun yuqori boshlang‘ich investitsiya xarajatlari kiradi. Bundan tashqari, turli tarmoqlar va joylarda uzluksiz ulanishni ta'minlash IoT texnologiyalarini qo'llaydigan logistika kompaniyalari uchun jiddiy muammo tug'diradi.

Ushbu qiyinchiliklarni engib o'tish va logistikada IoT dan samarali foydalanishni ta'minlash uchun ma'lum faollashtiruvchilar hal qiluvchi rol o'ynaydi. Bulutli hisoblash platformalari bilan integratsiya real vaqt rejimida ma’lumotlarni qayta ishlash va tahlil qilish imkonini beradi, qaror qabul qilish imkoniyatlarini oshiradi. Ilg'or tahlil vositalaridan foydalanish prognozli xizmat ko'rsatish va muammolarni proaktiv hal qilish imkonini beradi. Bundan tashqari, blokcheyn texnologiyasidan foydalanish ta'minot zanjiri operatsiyalarida ma'lumotlar xavfsizligi va shaffofligini oshirishi mumkin. Sanoatdagi standartlashtirish sa'y-harakatlari, shuningdek, turli IoT yechimlari o'rtasida o'zaro ishlashni osonlashtiradi.

Kalit so’zlar: Kiberxavfsizlik; O'zaro ishlash qobiliyati; Ma'lumotlarni boshqarish; miqyoslilik; Haqiqiy vaqtda kuzatish; Bashoratli texnik xizmat ko'rsatish; Avtomatlashtirish; Ma'lumotlar tahlili; Mavjud tizimlar bilan integratsiya; Manfaatdor tomonlarning hamkorligi; Texnologiyaga investitsiyalar.

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Chapter 1

Introduction

Preface

The use of Internet of Things (IoT) in the logistics sector has attracted much attention of scholars in the recent past because of the promise that it holds for the logistics sector. Through the use of IoT technology, it would be possible to track, monitor and optimize those processes used in the logistics fulfillment chain thus solving the problem of inefficiency and high costs. Thus, directly pointing to the positive aspect of using the IoT publicity in the implementation of its solutions in the logistics segment, it is necessary to mention certain factors that can be considered as challenges to its better integration, although they can be considered as its potential advantages.

1. 1 Research Questions

What are the most significant problems that one can meet when applying IoT in the field of logistics?

As stated earlier, what are the factors that have to be in place in order to enable organizations to achieve success when implementing IoT solutions in logistics?

The following factors need to be considered to understand which factors are most crucial for using IoT positively in the logistics industry:

1. Not only is there a need for standardisation in IoT implementation, there are also a few challenges when it comes to IoT in logistics.

Data Security and Privacy Concerns: One of the main issues which can be attributed to the implementation of IoT in the logistics industry is the concern towards the security of data interchanged within connected devices. Given that IoT sensors and devices are used to collect a large number of sensitive data about the users, they are especially susceptible to cyber threats and unauthorized access.

Interoperability Issues: The following is the elaboration of another challenge: There is no common layout and compatibility in the applied IoT devices and systems that support logistics undertakings. This can cause incompatibility of the data, there is creation of data silos and it also delays the flow of data in the supply chain from one stakeholder to the other.

Scalability: As logistics operation scales, scalability becomes a major issue which affects its implementation of IoT. Introducing IoT architecture that would support the increased amounts of data and connected devices is also an essential strategy that should be followed in the long term.

Cost Considerations: Some of the primary challenges when it comes to the adoption of IoT solutions in logistics include the high initial costs of implementing such solutions especially by firms that are in the starting stages of growth or firms that are small to medium sized. Another influential factor is that in terms of costs associated with hardware, software, connectivity, maintenance, and training an organization needs to obtain a positive ROI.

Enablers for Successful Implementation

Robust Connectivity Infrastructure: A strong and robust network connectivity showing high bandwidth is crucial in logistics operations corresponding to real-time IoT devices communication. These are technologies such as the 5G networks that may improve connectivity as well as creating a better platform for data transfer.

Advanced Analytics Capabilities: The AI and Machine learning is useful to analyze the data produced through IoT sensors that can provide valuable insights for the organization. Other benefits of predictive analytics include the easiest ways to manage supply chain, allotting resources in the right place, and better planning of routes.

Collaboration and Partnerships: In IoT implementation, there is the need for close-knit cooperation between various interested parties such as shippers, carriers, suppliers and technology providers. Supply chain cooperation can be leveraged to enhance knowledge sharing opportunities, resource sharing and even improvement of processes.

1. 3 Success Factors

Leadership Support: It is here that a later section covers the idea that commitment from 'top management' is crucial for 'internet of things' in logistics, a form of active reception process. The proponent needs to support change management initiatives, prioritize investments and create conditions conducive for implementing innovation projects.

Employee Training and Change Management: Ensuring that employees in an organization are well trained on how they should use IoT technologies is another important aspect in order to maximize on the gains. They proposed that there is need to adopt change management strategies that would deal with factors that create resistance to new technologies and processes within the organization.

Continuous Monitoring and Evaluation: Particularly, monitoring of KPIs that define the current state of IoT advancements and the approaches to be followed during their implementation is vital in order to assess the progress of the advancements' execution and make decisions dependent on the constant analysis of the identified data. This is justifiable because constant evaluation of a strategy is a way for organisations to make necessary changes due to the dynamics in the market and new technologies which keep on emerging.

If these challenges are mitigated and enablers harnessed together with its success factors, then organisations can realize IoT's optimum and optimise the logistics industry by it.

The use of IoT has been highly regarded in the logistics industry because of the potential of making drastic changes whereby; operational efficiency, visibility, and decision-making processes are improved. It is the intention of this thesis to establish the key hurdles, drivers, and antecedents in the adoption of IoT technologies in the logistics industry. When these areas have been analyzed fully, the intention is to offer some considerable knowledge that will aid an organization in enhancing their supply chain through the use of Internet of Things.

1. 4 Objectives in Implementing IoT in Logistics:

The use of IoT in the logistics system present several considerations that have to tackled properly to facilitate deployment. As known these challenges include Data Security and Privacy, heterogeneity, initially high investments, the lack of standardization or rather the insufficient standardization, and questions concerning the reliability and the extendibility of IoT Solutions in the sense of their aptness on complex supply chain environments.

1. 5 Enablers for IoT Adoption in Logistics:

However, there are several factors which help in the implementation of IoT in the logistic industry. Some of these enablers are ''smart'' sensors; cloud-based computing infrastructure for data storage and processing; advanced connectivity through the fifth Generation (5G) networks; proliferation of edge computing capabilities; and access to efficient analytics tools for making effective use of insights from the IoT generated data.

1. 6 Success Factors for Implementing IoT in Logistics:

Therefore, before the concept of IoT are applied in the sector of logistics some key success factors have to

be considered. These factors include; aggressive positioning of IoT vision with the organizational objectives, IoT being backed by strong leadership, introduction of change management strategies to support a new culture of working, cooperation with technology and service providers, ongoing evaluation of the IoT performance indicators, and efforts to develop a competent talent pool to manage IoT systems.

Thus, this thesis seeks, first, to explore the application of IoT in logistics and, in particular, identify and discuss the problems regarding its implementation, secondly, to reveal the factors that facilitate the application of IoT in logistics, and, thirdly, to define the key success factors to apply the IoT technologies in the supply chain environment.

Chapter Two

Literature Review

IoT has appeared to be disruptive in the logistics sector due to its ability in real-time data capturing, increase in visibility and efficiency. Nonetheless, it important to point out that the integration of IoT in logistics also comes with some drawbacks. This literature review will therefore aim at identifying the challenges, enablers and success factors of IoT for logistics.

The article published titled "Research to key success factors of intelligent logistics based on IoT technology" by (Chen, 2022) The Journal of Supercomputing is a subject to present detailed analysis of the key success factors of intelligent logistics through the adoption of Internet of Things (IoT) technology. Intelligent logistics can be defined as the use of technologies like AI, BIG DATA, IoT especially in the supply chain. Real time monitoring and tracking and decision making in logistics process becomes possible and effective with the help of IoT technology. The research by Chen et al. (2022) identifies several key success factors that are crucial for the effective implementation of intelligent logistics solutions: Supply chain network: Establishing good relation with other stakeholders promote interconnectivity and sharing of information thus enhancing interconnectivity. Security and Privacy: The appropriate protection of the data transmitted across these interconnected IoT devices call for proportional measures of cyber security for their continued use and reliability.

Supply chain digital technology enablers has been discussed by (Attaran, 2020) in section where pointing on effectiveness of supply chain. Technologies have significantly transformed traditional supply chain management; thus, presenting organizations with new prospects and risks. Digital enabling technologies in SCM Digital technology enablers refers to digital tools that support all aspects throughout the supply chain process. Such technologies include the internet of things (Iot), blockchain technology, artificial intelligence, Big data as well as cloud computing. This paper discusses each of these technologies in the context of its function as an enabler of efficiency in various supply chain activities. Concisely, this paper by Attaran (2020) presents that the enablers of digital technologies are instrumental in enhancing modern supply Chain. This brings into perspective these enablers and the implications that organizations should factor in when it comes to the changes in the supply chain management.

(Rajak, 2023) used factor analysis and presented a study that explores the success factors that determine Internet of Things (IoT) adoption for optimization of port logistics. Scholars have suggested that application of IoT in port logistics can augment industrial overhaul by increasing efficiency, security, product safety and real time information processing capacities. The use of IoT technologies in the port's logistics is vital to efficiency in the supply chain network management. Sensors, RFID tags, and GPS trackers of IoT devices can help in delivering real-time information concerning the whereabouts, state and condition of the cargo. This data can be used to rationalize operations, minimize downtime and enhance on general operations in ports. There is need to have strong technological framework that can support IoT application in port logistics. This includes network provision of service, cloud services, and data security provisions. The full implementation of IoT in the area of port logistics, requires effective cooperation of various actors ranging from port authorities, shipping companies, terminal operators, technology providers and others. The major issues to be solved are connected with the communication, so when objectives and aims are clear, it is easier to come through with ideas and become successful. Another challenge facing port logistics the protection of the data that is generated by IoT devices. Employing such measures like use of encryption and restrict access, hire of professionals security auditors are crucial for information protection against acts of cyber criminals.

Some studies of (Tran-Dang, 2022) discuss the Internet of Things (IoT) in the field of logistics from different points of view, and possibilities and problems concerning the IoT system. The IoT has been very impactful in addressing the issue of logistics as it provides information on tracking, monitoring and the overall improvement of supply chain. The authors argue on the development of IoT technology in the logistics systems pointing at enhanced visibility and efficiency arising from development of sensors, connectivity and data analytics in the supply chain. They key point which they come to focus is the capability of IoT devices in data capturing and transferring logistics chain data. Therefore, this study by Tran-Dang et al. (2022) provides a detailed discussion on how IoT contributes to reshaping the system of logistics. Their study underlines the importance of adopting IoT solutions, which would help increase the visibility and improve the practical effectiveness and sustainability of many different supply chain management practices.

Focusing on IoT applications in supply chain, more and more attentions have been paid in recent years because of the disruption it can bring to new supply chain modes. Other authors like Haddud (2017) explores the opportunities and risks linked to IoT implementation in the chains found in supply. Challenges of Internet of Things Integration in Supply Chains (Haddud, 2017) position the increase of the supply chain visibility and transparency as the primary benefit of integrating IoT. Real-time locating systems effectively monitor goods, assets or processes, giving insight to make the right decisions efficiently and cutting on costs. Moreover, IoT integration helps in achieving predictive maintenance and best use of equipment mainly through the time of usage of equipment. In addition to these benefits, smart supply chains enabled by IoT technology meets customer satisfaction through accuracy in order processing, short delivery cycle, timely identification of problems and their resolution. IoT technology's capacity to gather large quantities of data provide supply chain stakeholders with significant information for improvement in supply chain processes and future objectives.

There has been enormous interest over the years in the use of Internet of Things (IoT) in the logistics operations because of its possible impact in transforming the supply chain and transportation systems. Laosirihongthong (Laosirihongthong, 2019) offered a literature review on this subject in their publication entitled 'Logistics 4. 0: implementation of Internet of Things (IOT)' at the Welcome Message conference. The authors first introduced the topic of Industry 4. 0 also called the Fourth Industrial Revolution, is the implementation of technologies including IoT, cloud computing, artificial intelligence, and big data in manufacturing. Some scholars claimed that Logistics 4. 0 is a continuation of Industry 4. 0 to the logistics and supply chain management in their pursuit of providing more effective, adaptive and sensitive networks. Thus, Laosirihongthong et al. (2019) presented a relevant literature of IoT applications and prospects of their usage in logistics. Leveraging on internet, their work showed how IoT has the potential of creating responsive and efficient logistics network reducing the main problem afflicting today's business entities. Focusing on IoT applications in supply chain, more and more attentions have been paid in recent years because of the disruption it can bring to new supply chain modes. Other authors like Haddud (2017) explores the opportunities and risks linked to IoT implementation in the chains found in supply. Challenges of Internet of Things Integration in Supply Chains Haddud et al. (2017) position the increase of the supply chain visibility and transparency as the primary benefit of integrating IoT. Real-time locating systems effectively monitor goods, assets or processes, giving insight to make the right decisions efficiently and cutting on costs. Moreover, IoT integration helps in achieving predictive maintenance and best use of equipment mainly through the time of usage of equipment. In addition to these benefits, smart supply chains enabled by IoT technology meets customer satisfaction through accuracy in order processing, short delivery cycle, timely identification of problems and their resolution. IoT technology's capacity to gather large quantities of data provide supply chain stakeholders with significant information for improvement in supply chain processes and future objectives.

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This study was done by authors being (Gupta, 2021) where the author centered on digital enablers of supply chain performance. Technological incorporation in managing the supply chain has become rather vital to organizations that want to optimize their processes, time and performance. Overview of Digitization Technologies Digitalization technologies comprise a broad category of tools comprising an escalating progression of technological structures of enhanced supply chain affairs. These technologies includes but are not limited to Internet of Things (IoT), artificial intelligence (AI), blockchain, big data analytics and cloud computing. All the above technologies have their own contribution in revolutionizing the conventional supply chain management systems to digital models of supply chain solutions. Drivers of Supply Chain Performance Using digitization technologies, Gupta et al. (2021) outlined some of the enablers that have a big influence on supply chain performance if well harnessed. These enablers include:

Integrating the internet of things (IoT) technology in supply chain management has attracted key attention because of its impact in modern supply chain movement. (Chen, 2022) and (De Vass, 2021) discuss the prospects and issues concerning the implementation of IoT by organizations with relation to Industry 4. 0. IoT provides numerous benefits in business sectors when applied on the aspects of supply chain management and its visibility. Inventory monitoring, goods tracing in real-time, condition-based monitoring of assets, and demand forecasting are some of the domains where IoT can deliver significant values. Companies with the help of IoT devices, for example, sensors and RFID can track the movement of products along the supply chain, which consequently can help improve decision making. In this day and age, Internet of Things (IoT) technology is being embraced in different sectors including logistics. Thus, in the literature review by (Baurai, 2019), the author created a conceptual framework in order to determine the major factors or variables affecting the use of IoT to improve logistic performance. Communication is greatly facilitated in the logistics area as IoT has various capabilities including real-time tracking of goods, inventory, maintenance of vehicles and many more. These advantages have made organisations show more desire to implement IoT solutions in the logistics operations with the aim of enhancing operational efficiency and customer satisfaction. This is the readiness of an organisation to accept change and to integrate IoT solutions within its processes is another consideration. The factors that determine the effectiveness of Internet of Things (IoT) technology adoption and implementation in the current logistic activities include; organizational culture, leadership support, skilled employees, and change management strategies. Some of the limiting factors that have emanated with the implementation of IoT in logistics include the following; Appropriate mechanisms for secure data transfer, storage, and access have to be put in place to foster confidence among the stakeholders and to protect the information shared in the logistics community. Thus, the implementation of IoT technology may be viewed as a solution that can transform logistics by increasing its' elements' level of openness, which in turn can affect the entire supply chain. When analyzed in the light of technological infrastructure readiness, organizational readiness, data security measures, costs involved and regulation compliance necessities, it will be possible for organization to reap benefits from IoT solution for logistic performance enhancement.

In the paper by (Diwan, 2016) titled "Internet of Things in Logistics: In his article "Logistics Industry: Towards Autonomous Logistics & Smart Logistics Entities," the author discusses the IoT technology in the context of the logistic sector. IoT is explained as an array of objects that derive functionalities from the net and can automatically exchange information with one another. This has made a significant positive impact on various fields like logistics where real time tracking, monitoring and controlling of the processes is possible. Therefore, making use of the findings from Diwan's paper, it is, therefore, possible to establish that IoT is key towards the realisation of autonomous logistics operations and the development of smart logistics entities. Through the adoption of IoT technologies especially in the areas of real time data analytics and connectivity, logistic firms will be able to effect significant enhancement on process flows, decision making cycles and consequently provide even better services to their clients.

Internet of Things has impacted most industries including logistics where devices are physically

connected with other systems. (Song, 2020) a recent work included a systemic review to identify the various uses of IoT in smart logistics. The study by Song et al. (2020) highlighted the key IoT technologies that are transforming smart logistics operations. These technologies include RFID (Radio-Frequency Identification), sensors, GPS tracking, and cloud computing, among others. By leveraging these technologies, logistics companies can enhance visibility, traceability, and efficiency in their supply chain processes. In conclusion, the study by Song et al. (2020) provides valuable insights into the applications of IoT in smart logistics. By embracing IoT technologies strategically, logistics companies can streamline operations, improve efficiency, reduce costs, and deliver enhanced customer experiences.

As noted earlier, there has been a growing focus with regard to the adoption of IoT in the SCM since it has been seen as a tool that holds the potential of significantly altering traditional SCM paradigms. In their studies, (Abdel-Basset, 2018) analyze the effects of IoT on supply chain enterprises and provide an approach to building intelligent, secure and optimal supply chain systems. The use of IoT technologies entails tracking and monitoring the movement of goods, assets, vehicles and hence affords real time visibility of the supply chain process. The result is that decisions are made where they are needed quickly, thus improving the efficiency of the proceedings, lowering costs, and improving the satisfaction level of customers. Therefore, the incorporation of the IoT in supply chain plays the role of optimizing and even revolutionizing common supply chains to reflect improved visibility, better decision making processes, enhance costs and overall efficiency. However, such challenges as Data security, Interoperability, Scalability, and Skill gaps need to be addressed in order to allow the effective implementation of some strategies.

With Industry 4. 0 on the rise, lean manufacturing has had to incorporate Technology to improve processes in manufacturing and the supply chain. The critical success factors of Lean 4. 0 that have been analyzed in the studies of (Qureshi, 2023) aim at supporting the sustainable manufacturing supply chain of SMEs. Lean Manufacturing and Industry 4. 0 Lean manufacturing is one of the operations management methodologies that aims at eliminating wastes in the manufacturing processes so as to enhance productivity, quality and customer satisfaction. Industry 4. 0, on the other hand is the Fourth Industrial Revolution which is defined by the integration of digital technology with the conventional manufacturing industry. Difficulties Involved in the Integration of Lean 4. 0 to SMEs: Since the integration of Lean 4. 0 is a complex process, it is not easy for the SMEs to adopt this concept due to certain factors such as insufficient capital, less knowledge of implementing ideas and techniques, and resistance to change. Overcoming these challenges can only be a key for SMEs to stay relevant in today's highly dynamic business environment. Critical Success Factors for Lean 4. 0 Implementation Qureshi et al. (2023) have identified a number of success factors which have a significant influence in the effective adoption of Lean 4. 0 by SMEs. It can be concluded that CSFs presented by Qureshi et al. (2023) should be recognised and managed by SMEs that aim to incorporate Lean 4. 0 practices as part of the manufacturing supply chain in Industry 4. 0.

In his article 'Facing disruptive challenges in supply chain 4. 0. ', (Princes E. , 2020) examines disruption of technologies in the contemporary supply systems. Supply chain 4. 0 is a concept that is defined by the application of high technologies in supply chain management including the technologies like IoT, Artificial intelligent, big data analytics and the use of block chain.

Disruptive Technologies in Supply Chain 4. 0 According to Princes (2020) disruptive technologies are being applied and are redesigning the supply chain to focus on the visibility, transparency and efficiency. For instance, internet of things (IoT) facilitates real time tracking and monitoring on goods, artificial intelligence algorithms on logistic adhere to efficient storage and replenishing of stock while the blockchain guarantees secure and transparent transactions with the physical supply chain product. Challenges Experienced When Implementing Supply Chain 4. 0 The following is a list of factors that increase the level of difficulty that organisations face when implementing Supply Chain 4. 0. Challenges Faced in Supply Chain, article Challenges Experienced When Implementing Supply Chain 4. 0 Some of these challenges include information security, compatibility of the new technology with others already in place, lack of skilled workers in digital matters and organisational inertia arising from workforce that are set in their ways.

The recent trends in Research and development of Logistics service providers to incorporate Industry 4. 0 technologies. In a systematic literature review, (da Silva, 2023) sought to understand the Interaction dynamic between logistics service providers and Industry 4. 0. Industry 4. 0, which is the process of

integration of digital technologies into manufacturing industries and industrial processes has far reaching consequences for logistics service providers. Technologies like Internet of Things (IoT), Artificial Intelligence, Big Data and Automation may improve the logistics end-to-end processes in terms of speed, clarity and flexibility. This paper found the following gaps and prospects relevant to the adoption of Industry 4. 0 by logistics service providers according to the literature review. Some of the challenges include; data security, system integration, staff training and costs of initial implementation. On the other hand, the benefits include better supply chain transparency, prediction of equipment failure, tracking of products in real time as well as smooth and efficient service delivery to customers.

The work by (Kalkha, 2023) takes a look at prevailing and promising trends for smart e-commerce logistics based on the application of innovative technologies to increase the pace and quality of the supply chain. Smart E-commerce Logistics: The authors also point out on the role of smart e-commerce logistics, where IoT, AI, big data analytics and blockchain are used to enhance operations, inventory management and last mile delivery solutions. Integration of IoT in E-commerce Logistics: Now let us take a closer look at the major aspects that were covered in the paper, beginning with the integration of IoT devices into the logistics of e-commerce. Such devices let tracking the location of shipments, control the environment of the warehouses, and predict when vehicles require maintenance, which in its turn improves visibility and control of the supply chain.

(Yadav, 2020) did a research with the emphasis on the factors that enable the improvement of knowledge management for the logistics capabilities of Indian organizations. In particular, the implementation of knowledge management has a constructive impact on the enhancement of organizational performance in the most cases and for logistic operations in particular. Here it is found that the implementation of the knowledge management practices in any organization can enrich its logistic performance. Therefore it can be identified that through the proper and efficient management and application of knowledge assets organisations can significantly optimise and improve their supply chain activities, decision making, effectiveness, and overall business competitiveness. The authors Yadav et al. (2020) pointed out several factors that are important to KM implementation in organizations. Some of these enablers include; leadership support, in the organization culture, technology support, employee skill and knowledge acquired, knowledge sharing practices and procedures, and performance measurement systems.

(Dora, 2022) conducted a study focusing on the critical success factors influencing the adoption of artificial intelligence (AI) in food supply chains. The integration of AI technologies in supply chain management has gained significant attention due to its potential to enhance efficiency, reduce costs, and improve decision-making processes. : AI technologies offer various applications in food supply chains, including demand forecasting, inventory management, quality control, traceability, and logistics optimization. These applications can help organizations streamline operations, minimize waste, and respond effectively to changing market demands. The study identified several critical success factors that influence the successful adoption of AI in food supply chains. These factors include organizational readiness, top management support, data quality and availability, technological infrastructure, employee skills and training, collaboration with partners, regulatory compliance, and return on investment considerations.

Supply Chain 4 ‘is still very fresh and hence the following are some of the ideas associated with it. : Level 0 is the adoption of key technologies applied on supply chain management such as Internet of Things (IoT), Artificial intelligence (AI), big data analysis as well as automation. According to (Princes E. (., 2020), this is not just an evolution but a revolution that turns traditional supply chain into flexible, productive and effective supply chain network equipped for responding to variability of market dynamics and disruptions. A paper by Princes (2020) list the following disruptive challenges that organizations encounter in implementing Supply Chain. These challenges are; technological advancements, shifts in customers’ preferences, geopolitical risks and environmental issues. All these factors are known to present a supply chain risk that may affect the operation of many organizations hence calling for a strategic approach.

Blockchain has become increasingly popular across industries to improve the decentralised systems of transparency, effectiveness and security. When it comes to the application of blockchain technology for PDS, especially in India, it is necessary to identify the basic CSFs to determine how they may affect the usage of the technology. Based on the study done by (Vishnu, 2024) little research has been done in exploring these factors and; therefore , this research will make modest addition to theory building and real-

world applications. By so doing, blockchain technology shall provide a decentralized system of record keeping as well as within supply chains. From the literature, the usage of blockchain in the public sectors across the globe has been identified as having lots of utility in enhancing service delivery and minimizing fraud.

Making's key assumption is the beginning of the fourth Industrial Age, the consequences of which are still not fully felt as it is happening now. 0 has remodelled the conventional manufacture industry by embracing new technologies for increased productivity, efficiency and competitiveness. The paper by (Jimeno-Morenilla, 2021) brings about a study of various technological drivers that make it possible to move to the next level of industrial revolution referred to as Industry 4. 0, especially in regard to their applicability to conventional manufacturing contexts. The review by Jimeno-Morenilla et al. captures the essence of technology enablers that helps to move towards the Industry 4. It has been observed that no study has been conducted with 0 within traditional manufacturing sectors but at the same time it is important to know that organizations encounter various problems during this change. Mitigating these challenges through carefully spelt-out planning, talent management, and capital outlay will be important as the world transits to Industry 4. 0 technologies.

Specifically, the implementation and practice of digital interoperability have received a lot of interest in the area of logistics and supply chain management (SCM). Worldwide, industries are concentrating more resources on new technological improvements and, therefore, use and integration of different systems is crucial. As identified by (Pan, 2021) , the present paper aims to establish the current situations and developments relating to the digital interoperability, its effect on logistics and SCM, and the possible future research directions towards the realization of the PI. According to Pan et al. (2021), digital interoperability means the capability of various information systems, devices, applications, and services to exchange data seamlessly. It becomes vital in increasing operational effectiveness, decreasing costs, and increasing services' quality in supply chain networks. The authors categorize existing interoperability frameworks into three main types: that includes technical, semantic, and organizational interoperability.

This perishable food supply chain is a field into the effective establishment of supply chain which targets the food quality, safety, and sustainability. The advancement in technology in recent years has come up with new ways of dealing with these challenges. Thus, transformations that are at the exponent of the today's global supply chain; DLT, DT, IoT, and AI are promising opportunities for improving fresh food logistics. In this literature review, conclusions drawn from the literature will be used to preview (Vilas-Boas, 2023) in order to discuss the issues and prospects of this technological fusion. Therefore, let me provide some explanation of what exactly Digital Twins are before we proceed with the main topic: Digital Twins are virtual models of tangible objects that can mimic actual events. When referring to fresh food supply chain, DTs can measure and display temperatures as well as levels of humidity during and after transportation. Supplying real-time DT with actual DLT information is visible in Vilas-Boas et al. (2023), wherein incorporation of DTs with DLT can facilitate insights of supply chain that help stakeholders in decision-making based on real information. There are several advantages associated with the implementation of this approach these are; enhanced stock control, limitation of wastage resulting from more accurate demand estimation, and better quality control. However, this imposes a number of challenges, for instance, the development of efficient digital twins remains contingent on IoT sensors and data processing tools and systems. The authors also found out that there are technical issues that organizations have to deal with due to data integration and interface between different systems.

Due to the constant change of the speed of evolution in e-commerce and consumers' demands, on-demand logistics has become one of the essential aspects of the global supply chain. In this paper, (Lozzi, 2022) gives detailed information on this phenomenon, discussing different prospects, challenges and opportunities that define on-demand logistics. This literature review deconstructs some of the major points made by their works and places them into the general contexts of logistics and sustainability. Analyzing the study by Lozzi et al. (2022), it is possible to meet important solutions towards on-demand logistics while considering barriers and enablers that define this direction. When embracing e-commerce as a field of investment globally, these dynamics will assist the various stakeholders that are in place aiming to support innovation within this space as sustainability takes its fast-track journey.

Industry 4. 0 combined with lean six sigma is a shift in manufacturing practices that have sought to

improve efficiency, productivity and quality of products. This type of integration has been studied in detail in the work of (Zulfiqar, 2023) where the enablers and barriers of this integration, together with its benefits and the technologies involved, have been identified. This literature review collects primary findings into their outlined formula while situating them within the body of knowledge on Industry 4. 0 and Lean Six Sigma. Therefore, the study by Zulfiqar et al. (2023) provides useful insights on the complex interaction between Industry 4. 0 technologies and Lean Six Sigma methods in manufacturing environments. Through presenting enablers that include leadership commitment and engaging employees and barriers including resistance to change and high costs of implementation, they add useful knowledge that organizations require in handling the situation. Furthermore, identifying possible advantages associated with this integration from operational efficiency to sustainability indicates the need to adopt this integration in today's manufacturing systems that are characterized by rapid advancement in technology. Thus, as industries continue to progress toward 'knitted' systems and integration strategies as well as data-driven decision-making elements, the need for further studies will remain necessary in identifying challenges to these ideas and the best practices of fully exploiting this single complementary solution.

Supply Chain 4. 0 is the enhancement of supply chain with the help of IoT, Artificial Intelligence, Big Data Analytics and Blockchain technologies. This change is conducive to increasing the effectiveness, openness, and flexibility of the supply chains. Nevertheless, there are impressive breakthroughs that yield correlated cyber security threats ought to be solved in regards to supply chains' integrity and security. (Sobb, 2020) highlight several areas for future research that could further enhance understanding and management of cyber security within Supply Chain 4. 0: Integration of AI with Cyber Security Protocols: That is why, its further integration into the existing frameworks of cybersecurity can open new opportunities and enhance defending against various threats. Impact Assessment Studies: Studying effect of different types of cyber threats on supply chain will be beneficial for organizations to mitigate factors which result in disruption. Development of Standardized Frameworks: Developing best practices for cyberspace security of supply chains in different sectors could also help in simplifying efforts of protecting supply chain all over the world. Exploration of Emerging Technologies' Impacts on Security Posture: As those or similar technologies become main stream it will be imperative to look into how current methods of encryption will be impacted by such next generation technologies as quantum computing. Longitudinal Studies on Cyber Security Trends in Supply Chains: Such approaches could give long-term understanding of how threats emerge and change across the sectors which could help with preparing for the further development of new risks. Thus, Supply Chain 4. 0 opens up vast opportunities for increasing performance through the implementation of new technologies, valuable in terms of supply chain management, at the same time it poses serious cyber security threats that require timely and efficient solutions through the activities of all interested parties.

Omni-channel retailing refers to a system of making sales through physical retail outlets, virtual retail outlets, and through the use of portable devices such as mobile phones. This is a strategy that seeks to ensure customers are are not restricted in the route that they have to go through in order to carry out a purchase. With the help of digital technology consumers have become more selective about the products acquired, but continue to remain loyal patrons of supermarkets, for whom convenient and personalize omni-channel purchasing paths have become the norm. Omni-channel: Understanding the Concept and Its Significance Logistics is a critical factor in omni- channel retailing since it has a bearing on cost and customers. Logistics means efficient delivery, proper storage, and reasonable charges for good's supply. It is pointed out in the research of (Mishra, 2023) that growing logistics experience is critical to increase customer satisfaction and obtain competitive advantage in the retail industry.

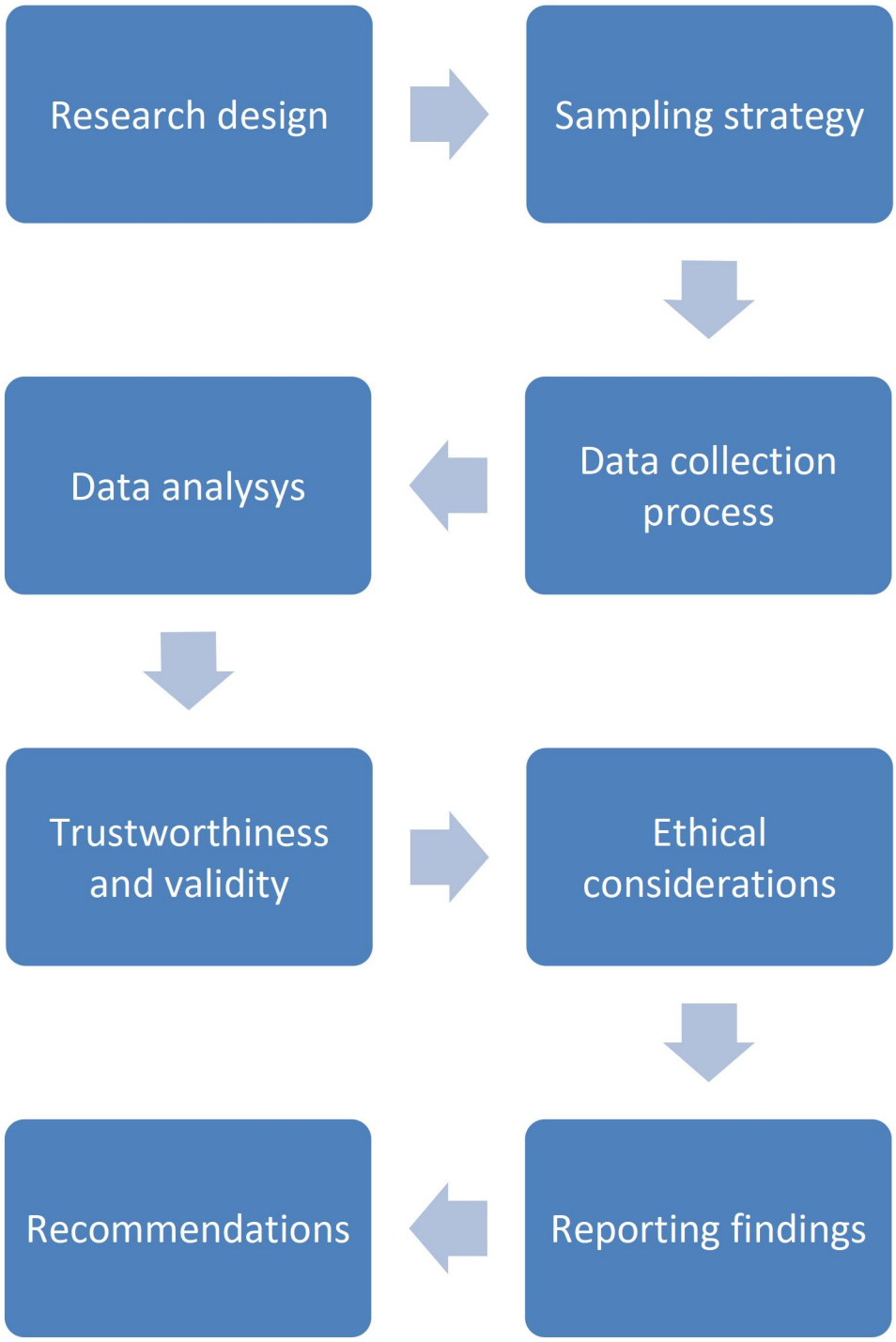
Artificial Intelligence (AI) implementation into production systems is an emerging interest area more so because industries strive to increase effectiveness, efficiency, and competitiveness. Based on the study done by (Merhi, 2023) this paper seeks to review the literatures identifying the enablers that enhance the adoption and instantiation of AI technologies in production settings. This literature review presents findings derived from their overall study, and also places their study in the current literature. Merhi and Harfouche (2023) extend the extant theory regarding technology adoption including the TAM, Diffusion of Innovations Theory and RBV. These frameworks assist in explaining the factors affecting an organisation's choice of AI implementation based on organisational properties, technological properties and environment properties.

It will be seen that actualization of smart manufacturing systems is evolving as critical focus of attention

for small and medium-sized enterprises, especially in India due to technological innovations and expansion requirements. Various authors have discussed SCFs in similar organisational contexts, including other authors who have outlined SCFs important to the effective implemention of SMS in the Indian SMEs specifically; (Shukla, 2024) . While synthesising their learnings into the existing literature on smart manufacturing, some core themes, methods, and adverse impact have been identified. Smart manufacturing can be explained in terms of manufacturing system that incorporates the application of Internet of Things (IoT), artificial intelligence, big data, and automation in the manufacturing process. The purpose is to increase efficiency, organisational adaptability, and the ability to meet customer requirements. This is why Shukla and Shankar are right in pointing out that while adopting SMS, organisations are changing their culture as well.

There has been unprecedented changes in the automobile industry mainly due to advancing technologies and global environment concerns. The use of IoT in Automotive supply chain offers a remarkable opportunity to improve its efficiency and to support the transformation to sustainable business models. (El Jaouhari, 2023) put forward a framework which focuses on the environmental-based approach in this integration process. Sustainability of Automotive Supply Chains As is shown, sustainability of automotive supply chains is multifacted and may pertain to resource utilization, waste management, and emissions. To the authors' concerns, prior supply chain models fail to bring environmental factors into account and, as a result, become less efficient and more destructive for the environment. It is possible to state the following proposition that will underscore the key argument of the paper: Sustainable management methods not only correspond to the legal requirements but also contribute to the development of the companies' positive image and increased customer loyalty. IoT as a technology IoT is one of the most significant technologies that contribute in reshaping automotive supply chains by facilitating data gathering and processing. The connectivity enables the visualization of the related chain and hence enhances the decision-making systems. El Jaouhari et al. explain that IoT devices can be used to assess vehicle efficiency, control stock, and manage physical supply chain flows. Such capabilities help in leveraging operation cost while increasing market response capability.

Chapter three
Methodology



1. 1 Research Design:

This research intended to identify the rationales and hurdles for implementing of IoT in logistics sector as well as the logistics IoT success factors. The quantitative data collection method was used in this study through administering a Google survey to getdata from the participants who were involved in the logistics industry. An interpretive approach will also be adopted with special emphasis on phenomenology for data collection in capturing the perceptions of key stakeholders in the logistics industry on the use of IoT.

Data Collection Method: Semi structured interviews and focus group discussions will be carried out with employees in the logistics industries, the IoT technology developers and the different companies that adopt the use of IoT technologies in logistics.

1. 2 Sampling Strategy:

The aim of the survey was to get as many points of view as it was possible concerning the topic under consideration. It comprised of questions such as the burning issues in the implementation of IoT in the logistics sector, enablers that facilitate IoT integration in the logistics supply chain and success influencing factors that determine the deployment of IoT. Purposeful sampling method will be used to target participants who have actual practice or study in concern of the interconnectivity in logistics. Interviews and focus group will be conducted to 20-25 participants from the International Silk Road university of tourism and cultural heritage so as to get a broad perspective.

1. 3 Data Collection Process:

In-depth interview will include self-administered interview administered to the key participants through one-on-one interview about their experience in using Google survey via telegram in logistics. There will be group discussions which will aim at getting participants talk as a group and express group opinions regarding the identified challenges, enablers and success factors. The Google survey was administered through channels that included subject specific forums, business related professional networks, Google related Facebook groups etc. .

1. 4 Data Analysis:

Thematic Analysis: The authors' interviews and focus group discussions will be transcribed and subjected to thematic analysis highlighting some of the concerns raised, enablers and critical success factors when applying IoT in logistics. After the surveys were conducted, the responses received were combined and statistically processed with the help of certain tools and applications. Quantitative analysis was utilised to describe the study outcome in percentage, frequency and average where appropriate. Coding will be used in a way to sort the answers received and get patterns that represent trends and challenges and opportunities that are common.

1. 5 Trustworthiness and Validity:

Triangulation: To increase confidence in findings interviews and focus groups data will be collected and analyzed.

Member Checking: As a way of evaluating the research, participants will be given a chance to go through the preliminary data collected in order to verify findings and conclusions made.

1. 6 Ethical Considerations:

Informed Consent: All the participants will be given consent forms that will contain information on what the study involves, procedures to be followed to ensure subject anonymity and subject's rights as research subjects.

Anonymity: Participants' anonymity and responses shall be kept discreet all through the study.

1. 7 Reporting Findings:

Research outcomes including common issues, factors that support, and those contributing to success in the use of IoT in the field of logistic will also be presented in a research report. Some of the problems posed by participants were: high costs of implementation, problems with integration with current systems, security, and organisational culture.

These included; support from top management, operationalization of IoT employee training, partnerships with technology partners and communication strategies.

According to the received answers, the key success factors included in IoT solutions were real-time data processing abilities, expansion capabilities of IoT solutions, existence of compatibility with other innovative technologies such as AI and Blockchain, and last but not least correct cyber security strategies.

Overall, the study highlighted complex nature of applying IoT in logistics hence laying emphasis on the subject area. Quantitative data gathered from a Google survey helps in depicting the challenges, enablers, and success factors of IoT- based applications and enable organizations to devise better strategies for IoT related activities to overcome barriers and improve operational performance in the complex and competitive logistics sector. Applying the findings of the conducted research, recommendations will be made for countering threats and realizing enablers for IoT logistics integration at organisations.

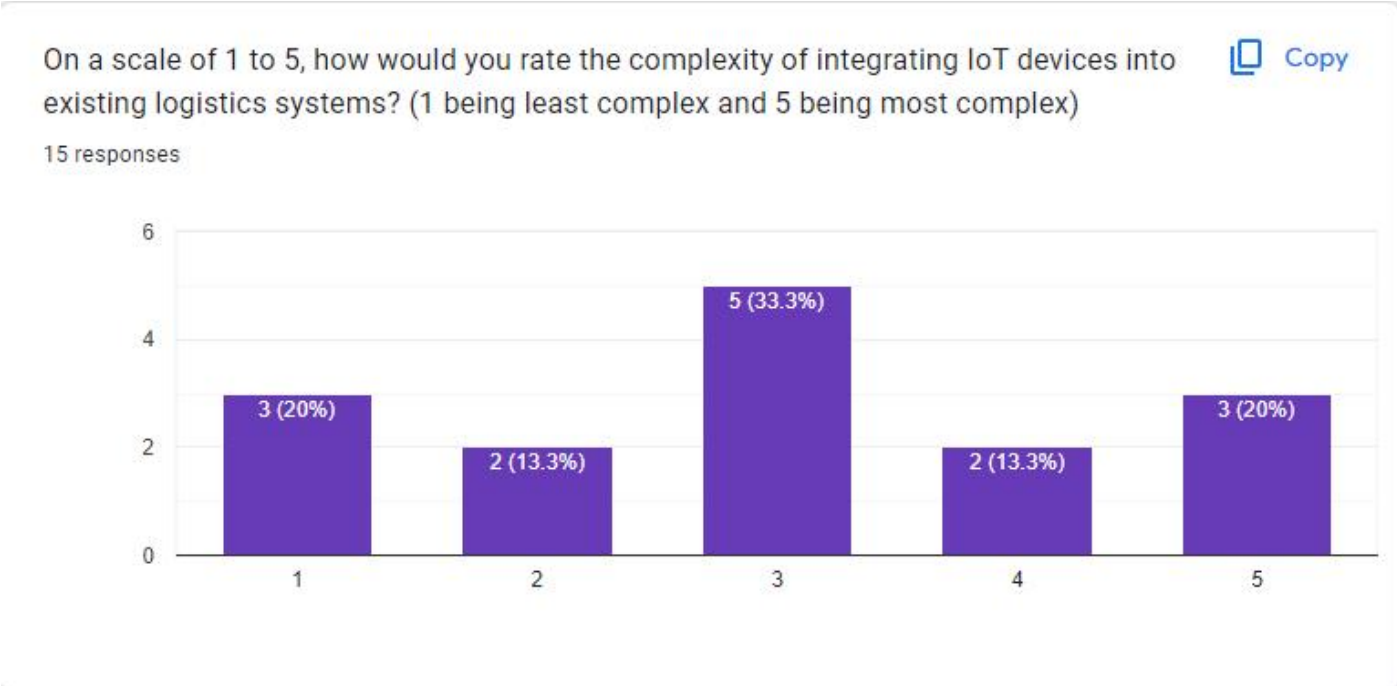
Chapter four

Results and discussion

The results section of this study presents the findings obtained through a quantitative data collection method using a Google survey on the topic of "Application of IoT in Logistics – Challenges; Enablers & Success Factors." The utilization of IoT (Internet of Things) in the logistics industry has gained significant attention due to its potential to revolutionize operations, enhance efficiency, and improve overall supply chain management. This study aims to explore the challenges faced, enablers identified, and success factors associated with implementing IoT technologies in logistics operations.

Table 1

On a scale of 1 to 5, how would you rate the complexity of integrating IoT devices into existing logistics systems? being least complex and 5 being most complex)



According to answers of this question, it is visible that most people thought that it is neither most complex nor least complex to integrate IoT devices into logistics system.

Table 2

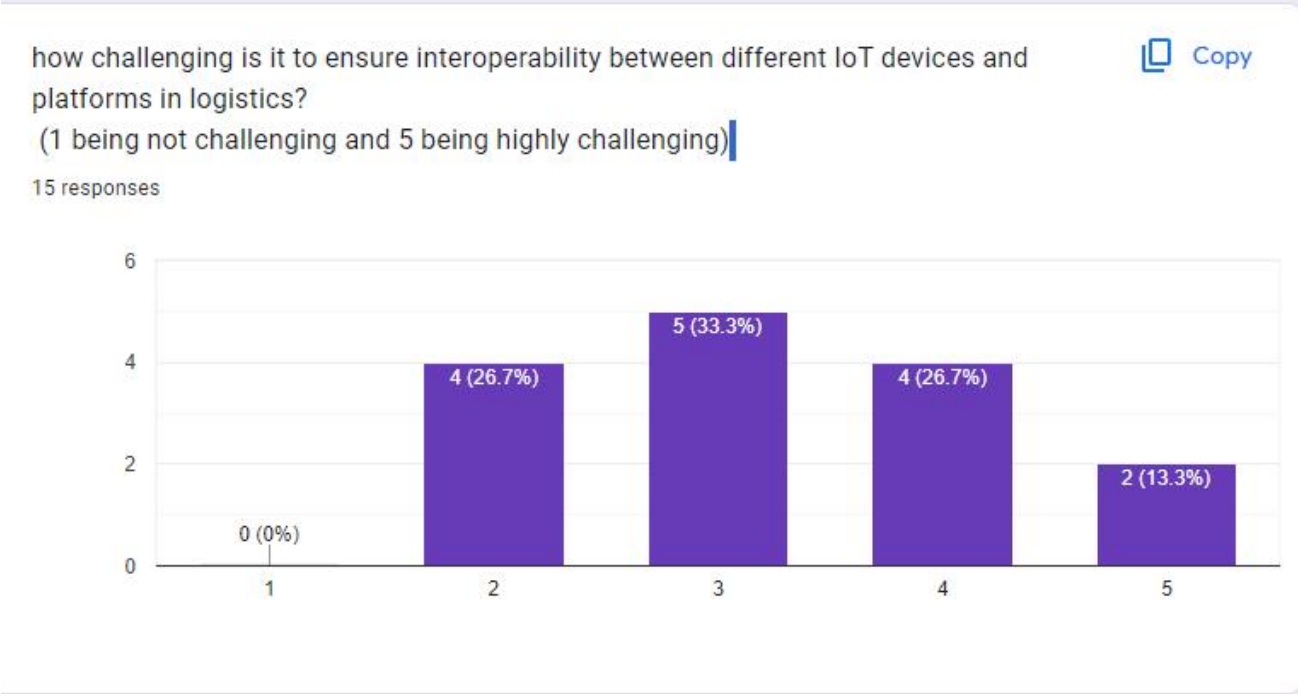
How significant is the issue of data security and privacy when implementing IoT solutions in logistics? (1 being not significant and 5 being highly significant)

According to research, to implement IoT solutions in logistics , data security is so important that 53,3%

interviewers chose highly significant.

Table 3

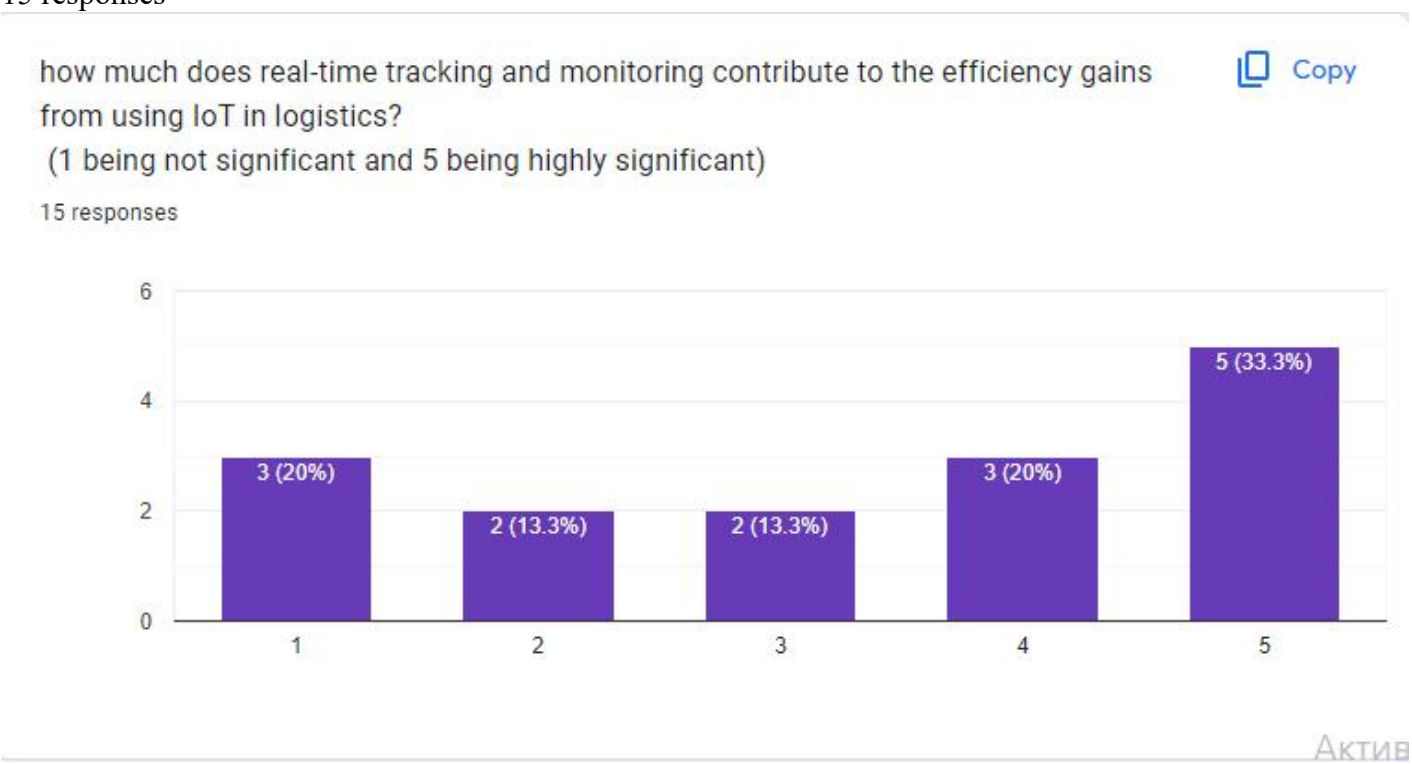
How challenging is it to ensure interoperability between different IoT devices and platforms in logistics?
(1 being not challenging and 5 being highly challenging)
15 responses



33,3% people that was on top choose difficult in medium rate to ensure interoperability between different IoT devices and platforms in logistics. Moreover, very few people find it highly challenging by 13.3%.

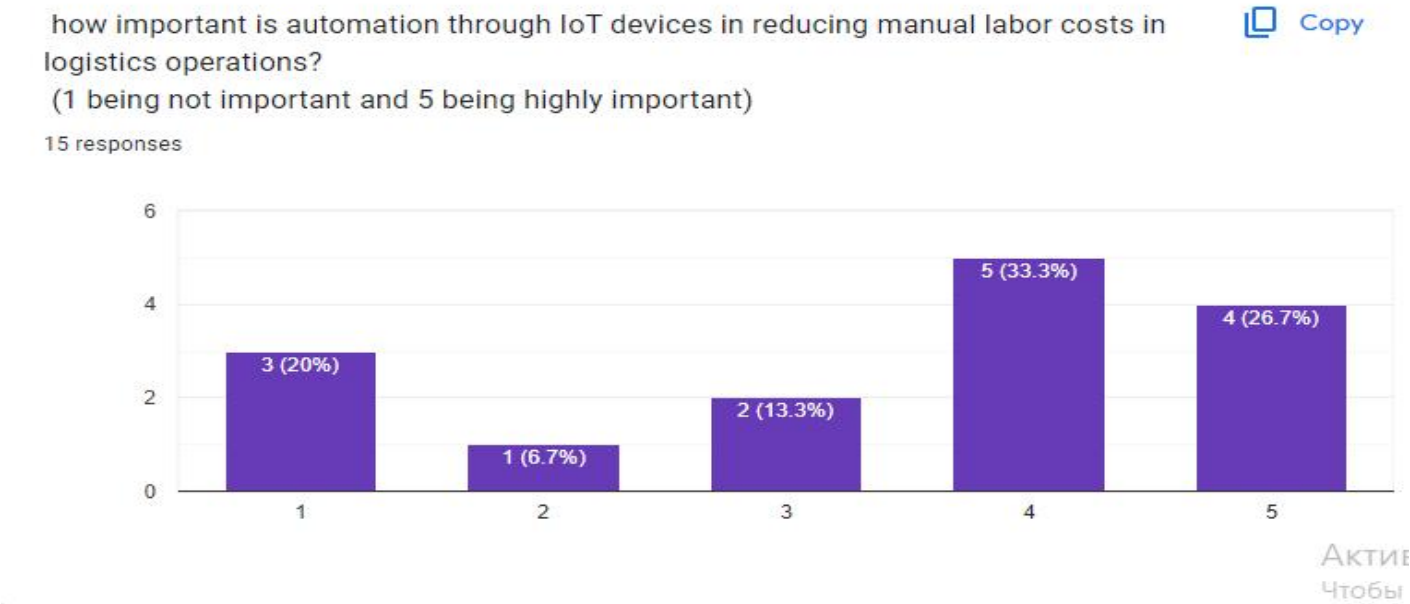
Table 4

How much does real-time tracking and monitoring contribute to the efficiency gains from using IoT in logistics?
(1 being not significant and 5 being highly significant)
15 responses



In this question, it was asked that how real time tracking and monitoring changes efficiency from using IoT in logistics. It is demonstrated that most people replied most significant.

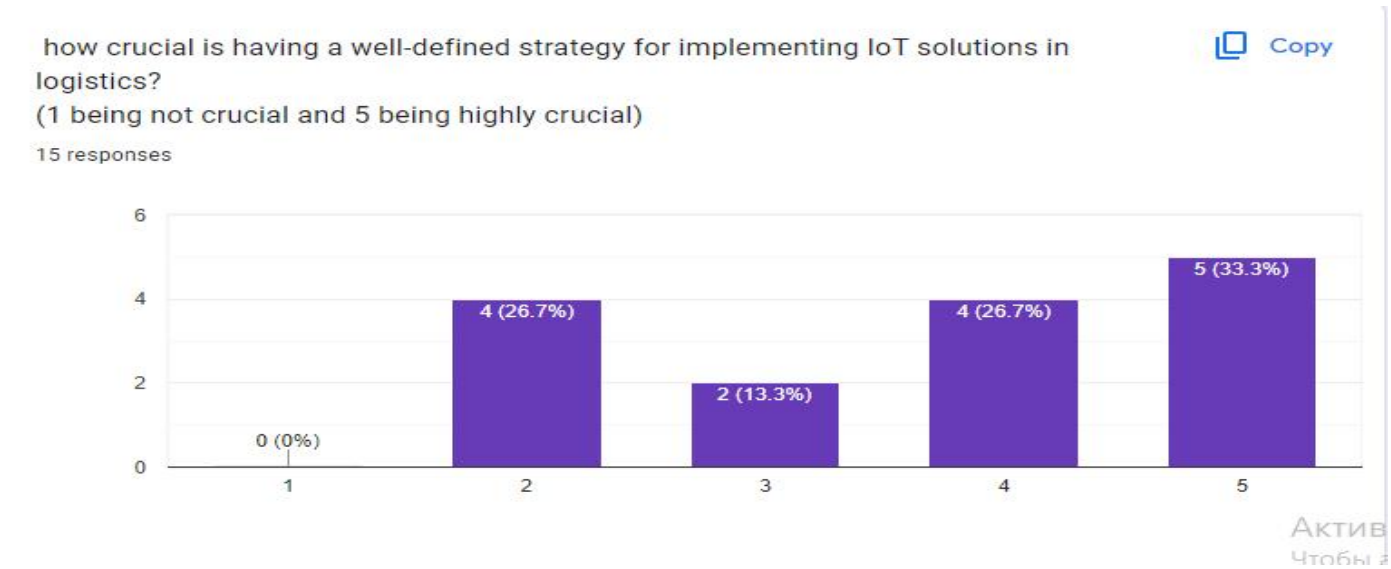
TABLE 5
How important is automation through IoT devices in reducing manual labor costs in logistics operations?
(1 being not important and 5 being highly important)
15 responses



Here we can see that the significance of automation through IoT devices in decreasing manual labor costs in logistics operations. And, it is clear that most interviewers choose high important in a scale.

Table 6
How crucial is having a well-defined strategy for implementing IoT solutions in logistics?
(1 being not crucial and 5 being highly crucial)
15 responses

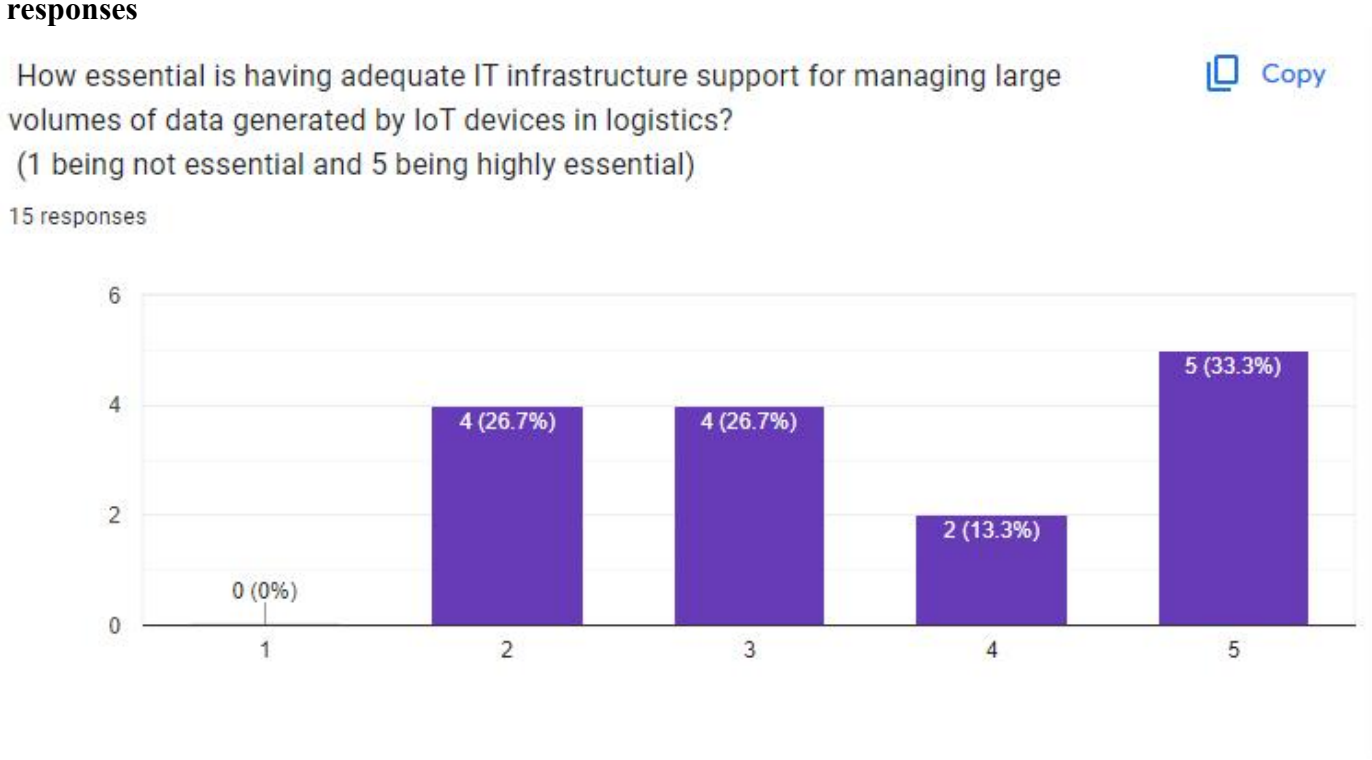
In



In logistics, it is important to have a professional strategy to implement IoT solutions. According to research any of interviewers do not agree that it is significant to have experienced strategy for implementing IoT

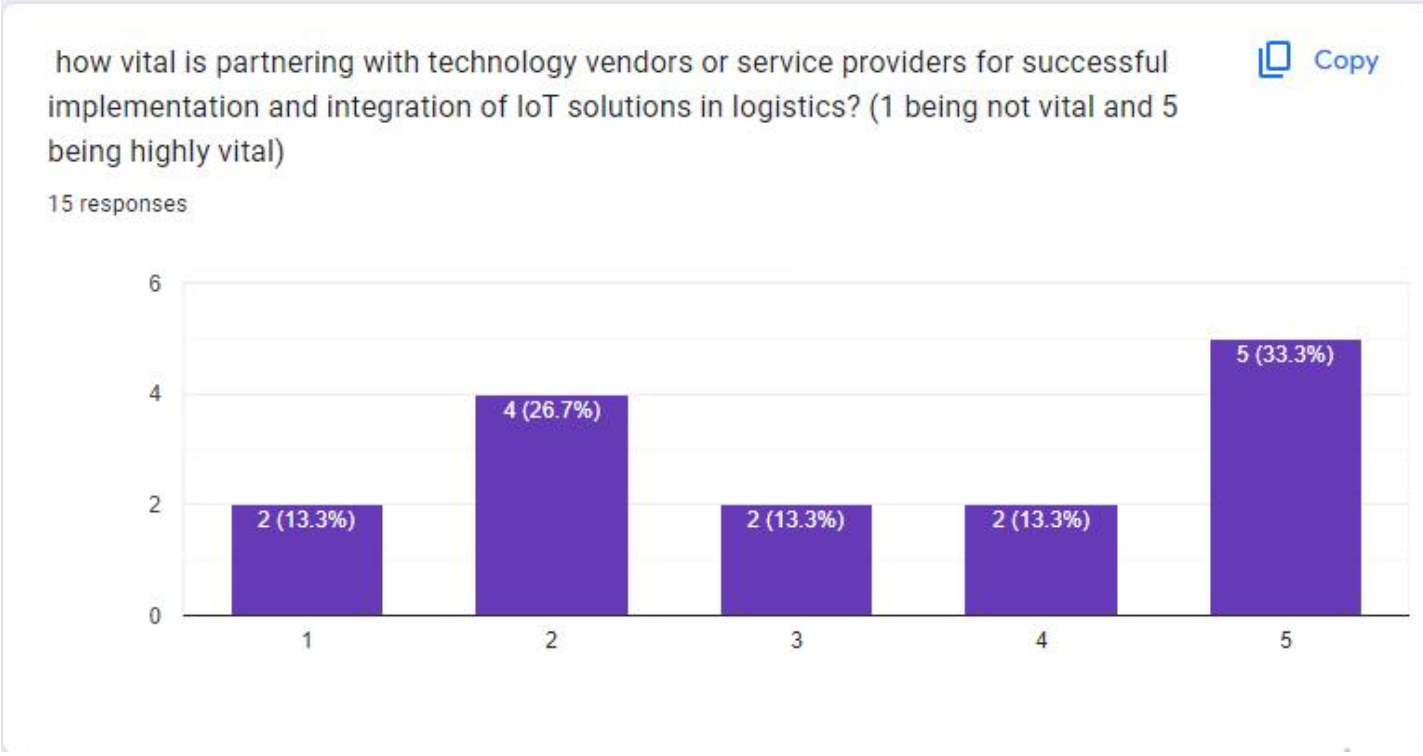
logistics.

Table 7
How essential is having adequate IT infrastructure support for managing large volumes of data generated by IoT devices in logistics?
(1 being not essential and 5 being highly essential)
15 responses



To have an adequate IT infrastructure support is not just beneficial but essential for managing large volumes of data generated by IoT devices in logistics effectively. It enables organizations to store vast amounts of information securely, process it rapidly for real-time analytics, maintain reliable connectivity across networks, integrate seamlessly with existing systems, and leverage advanced technologies like AI for enhanced decision-making capabilities. Failure to invest in a robust IT framework could hinder operational efficiency and expose organizations to significant risks.

Table 8
How vital is partnering with technology vendors or service providers for successful implementation and integration of IoT solutions in logistics? (1 being not vital and 5 being highly vital)
15 responses



Given the multifaceted benefits outlined above—ranging from expertise transfer to risk mitigation—the importance of partnering with technology vendors or service providers for successful implementation and integration of IoT solutions in logistics is rated as follows:

These partnerships are essential not only for overcoming technical challenges but also for ensuring strategic alignment between technological capabilities and business objectives within the logistics sector.

Chapter five: Conclusion and recommendation

By the same token, it is clear that there are some inherent difficulties in the implementation and utilisation of IoT within the logistics environment, however, practical enablers and direction towards recognised CSFs can be useful for organisations to address these issues and ensure the best potential of the IoT technologies can be achieved. Realization patterns in IoT implementation for logistics are; there must be a well-coordinated plan by the management, the other stakeholders have to agree and embrace the IoT systems, constant evaluation on the IoT systems, staff have to be trained on the new IoT technologies, and business intelligence has to be embraced for decision making. These challenges when tackled, the application of enablers, and consideration of success factors exposes companies to numerous opportunities to establish and design an efficient and effective supply chain, gain credibility, increase efficiency and cut down on cost thus gaining a competitive advantage in the market.

Key Challenges in the Application of IoT in Logistics: Below are some of the main problems that IoT encounter in implementation for its application in logistics: Such hurdles consist of data protection, incompatible IoT devices, and systems, high initial capital costs, absence of standard communication interface, and doubts about IoT capability in unpredictable logistics settings. Nevertheless, there are enablers that would help enable the proper implementation of IoT in logistics operations. Some of these enablers are; Increased reliability of sensors, available connectivity like 5G, availability of cloud as well as edge computing, and adoption of blockchain in sharing of data, and the increasing digitalization and automation of the logistics sector. Thus, the issues relating to critical success factors that should be considered to improve the application of IoT in the logistics sector are the following: Such critical success factors are as follows: Establishing proper cyber security measures to safeguard the sensitive information, establishing a close coordination with the stakeholders in order to ensure compatibility and conformity, recruiting and maintaining the pool of talents who are well versed with IoT technologies, constantly evaluating the IoT systems with a view of enhancing efficiency and identifying the ways to align the IoT initiatives with corporate goals.

Recommendations

It is imperative that companies adopt a clear biomap of how IoT is going to be implemented in the business.

One of the key components that are required in influencing change across the organisation is leadership commitment.

It is important to get a proper workforce to manage IoT technologies because the right skills are required for this sort of thing.

Hiring education-based courses on IoT competencies will enable employees to leverage on these technologies.

Entering the IoT world is a systematic shift that implies the need for effective change management to prevent employees' resistance and organisational disturbances.

One could also involving the employees in the process early enough through workshops or pilot programs that can help to ease change.

Evaluating the IoT systems frequently makes it possible to identify whether the running systems are addressing the new requirements of the business.

About efficiency, you will need to introduce certain KPIs that would enable you to measure progress over time, such as efficiency gains or cost savings.

It is crucial to figure out customer requirements while deploying IoT due to the fact that it enables technology to be used for its performance, rather than for the sake of using technology.

Customers' views regarding services that IoT facilitates can be collected with a view to directing future improvement.

As outlined, there are numerous challenges facing IoT in logistics, for example, they include the aspects of security and the high initial costs of implementation that come with it; however, there are enabitors such as the enhancement in the technologies of using sensors and the cloud computing solutions available currently to support IoT logistics. It is possible to overcome such challenges and fully utilise IoT capabilities for improving logistics operations through focusing on the matter of key success factors like, strategic vision and skilled human capital development.

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4. Appendices

Appendix A

1 On a scale of 1 to 5, how would you rate the complexity of integrating IoT devices into existing logistics systems? being least complex and 5 being most complex).

2. How significant is the issue of data security and privacy when implementing IoT solutions in logistics? (1 being not significant and 5 being highly significant)

3. How challenging is it to ensure interoperability between different IoT devices and platforms in logistics? (1 being not challenging and 5 being highly challenging)

4. How much does real-time tracking and monitoring contribute to the efficiency gains from using IoT in logistics? (1 being not significant and 5 being highly significant)

5. How crucial is having a well-defined strategy for implementing IoT solutions in logistics? (1 being not crucial and 5 being highly crucial)
6. How crucial is having a well-defined strategy for implementing IoT solutions in logistics? (1 being not crucial and 5 being highly crucial)
7. How essential is having adequate IT infrastructure support for managing large volumes of data generated by IoT devices in logistics? (1 being not essential and 5 being highly essential)
8. How vital is partnering with technology vendors or service providers for successful implementation and integration of IoT solutions in logistics? (1 being not vital and 5 being highly vital)