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Table of Contents

Leveraging Information Technology for Effective Inventory Management in Singapore's Supply Chain Industry

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Abstract

***Purpose**: The purpose of this research is to explore how a common IT system is used to manage inventory, and to identify the factors and challenges that affect the decision and implementation of IT adoption in inventory management.*

***Design/methodology/approach:** The methodology of this research consists of two parts: a literature review and primary research. The literature review synthesizes the existing studies on IT adoption in inventory management and provides a theoretical framework for the analysis. The primary is based on qualitative research design which involves conducting in-depth interviews with four inventory managers who use different IT systems across various industries. The interviews are transcribed and coded, and the data are analysed using thematic analysis and cross-case comparison.*

***Findings:** The findings of this study show that inventory managers adopt IT mainly to reduce costs and increase efficiency, which aligns with the literature. However, they also encounter challenges such as skill competencies and resistance to change, which hamper the successful implementation of IT. Moreover, the findings reveal that the type of IT system and the industry context may have an impact on the outcomes of IT adoption. Specifically, the inventory managers who use ERP, such as SAP, experienced more benefits and fewer difficulties, and the inventory managers who work in manufacturing and retail industries face more complex and dynamic inventory situations than those who work in service and education industries. These findings suggest that IT adoption in inventory management is not a one-size-fits-all solution, but rather a context-dependent and system-specific process that requires careful planning and evaluation.*

***Research implications and limitations:** This study offers practical insights and recommendations for inventory managers and IT developers who seek to improve their inventory management practices and systems. It also highlights the importance of IT for enhancing supply chain management and operational performance, which is a key goal of inventory management. However, this study is limited by the small and self-reported sample and the focus on two common IT systems. Future research could use larger and more diverse samples, multiple data sources, and different IT systems.*

***Originality:** This study addresses the research question of how IT is used to manage inventory, and what factors and challenges affect the decision and implementation of IT adoption in inventory management. It adds to the literature on IT adoption in inventory management by comparing multiple case studies with different IT systems and industries. It reveals the common and unique factors and challenges that influence IT adoption and suggests practical implications for inventory managers and IT developers.*

***Keywords:** ERP; Information Technology; Inventory Management; Resistance to change; SAP; Skill competencies.*

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Introduction

Supply chains are often simple systems of firms with dyadic ties and independent nodes and connections for producing goods or services. Contracts and different flows of material, information and capital are key connections (Chen & Wen, 2023). In the past, departments managed products and orders separately and with different goals. Past articles stressed SCM at all levels and across the widest network scope. Today's complex and uncertain world needs new models and strategies from technology. Innovative supply chain strategies, tools and approaches with ethical and environmental issues make SCM a performance driver (Tipi & El Gazzar, 2021). Inventory management balances consumer needs and supplier supply, affecting the whole supply chain. It involves tracking and controlling vendor and customer orders, and estimating and fulfilling available merchandise (Dang et al., 2020). It is part of SCM that manages the efficient and effective flow and storage of goods, services, and information from origin to consumption (Singh & Verma, 2018). It is also a key element of SCM that avoids supply disruptions and stock-outs by ordering the optimal amount and time while reducing storage and financing costs (Wang et al., 2022). Inventory management improves financial performance and competitiveness by saving costs in logistics activities. It is a strategic and vital operational function (Vukasovic et al., 2021a). Information sharing and visibility are important for deciding inventory levels and reorder points.

Inventory management is an important part of supply chain management (SCM) that balances consumer demand and supplier supply, affecting the whole supply chain (El Sakty, 2023). It involves tracking and controlling vendor and customer orders and estimating and fulfilling available merchandise. It is also a key element of SCM that avoids supply disruptions and stock-outs by ordering the optimal amount and time while reducing storage and financing costs. Inventory management improves financial performance and competitiveness by saving costs in logistics activities. It is a strategic and vital operational function (Vukasovic et al., 2021b; Fancello, 2022).

Information technology (IT) is the use of computers, software, networks, and other devices to create, store, process, and communicate information. IT plays a crucial role in inventory management, as it enables the collection, analysis, and sharing of data related to inventory levels, demand patterns, order status, and delivery schedules. IT also facilitates the automation, integration, and coordination of inventory processes across the supply chain, such as forecasting, replenishment, allocation, and distribution. IT can help improve the accuracy, efficiency, responsiveness, and flexibility of inventory management, as well as reduce errors, costs, and waste (Akour et al., 2022). One of the latest trends of IT in inventory management is cloud technology. Cloud technology is a type of IT service that provides access to shared resources, such as software, hardware, data, and networks, over the internet. Cloud technology can offer many benefits for inventory management, such as:

- Scalability: Cloud technology can adjust to the changing needs and demands of inventory management without requiring additional investment or maintenance. Cloud technology can also handle large volumes of data and transactions without compromising performance or security.
- Accessibility: Cloud technology can enable real-time access to inventory information from any device and location. Cloud technology can also support remote collaboration and communication among supply chain partners and stakeholders.
- Innovation: Cloud technology can enable smart devices and machine-to-machine communication, which can transform many aspects of inventory management. For example, cloud technology can support the use of radio frequency identification (RFID), internet of things (IoT), artificial intelligence (AI), blockchain, and big data analytics to enhance inventory visibility, traceability, optimization, and automation (Tjahjono et al., 2017; Ibrahim & Samrat, 2021).

Therefore, cloud technology is a promising trend of IT in inventory management that can improve the performance and competitiveness of SCM practices.

Supply chain management practices (SCMP) link all suppliers, manufacturers, distributors, and customers with information sharing. It was deduced that trust, information sharing, joint relationship management, and asset-specific relationships drive supply chain partner management (Basheer et al., 2019). Another article said information exchange is vital for supply chain performance and collaboration. More transparency and openness can enhance operational

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efficiency and flexibility by improving communication and information sharing. Higher integration and information sharing help understand different parties' needs and improve cooperation and coordination between them, leading to better decision-making and responsiveness in supply chain operations, order fulfilment and customer satisfaction (Fatorachian & Kazemi, 2021).

Consequently, the research purpose of this study is to investigate how information technology can improve the efficiency, effectiveness, responsiveness, and competitiveness of inventory management and SCM practices. Furthermore, the following research objectives are based on the significance of information technology and information sharing:

- To outline the various types of information technology used for inventory management.
- To explore the drivers of adopting information technology in inventory management.
- To identify the challenges of adopting information technology.

Literature Review

Managing Inventory with Information Technology (IT)

Inventory management is a central management function that involves the strategic planning, coordination, and supervision of the movement of materials and finished goods from suppliers to customers (Munyaka & Yadavalli, 2023). It emerges as a multifaceted and ever-evolving process that requires careful analysis and informed decision-making based on reliable and up-to-date information. The primary objective is to balance supply and demand, while minimizing inventory costs and risks, and maximizing customer satisfaction (Farahani et al., 2019). Various methods and approaches are employed to achieve these goals, such as just-in-time, materials requirement planning, economic order quantity, and days sales of inventory (Ghobbar & Friend, 2018). Supporting the inventory management process are diverse information technologies (IT) that facilitate the collection, processing, and dissemination of inventory-related data. By leveraging IT, inventory management benefits from improved visibility, accurate forecasting, efficient optimization, automation, seamless integration, and enhanced collaboration among stakeholders (Kmiecik, 2023). However, the incorporation of IT also poses certain challenges and constraints, such as data quality, security, privacy, interoperability, scalability, costs, user acceptance, standardization, integration, validation, evaluation, and generalization issues (Munyaka & Yadavalli, 2023). Additionally, Oluwaseyi et al., (2017) expounded inventory control as a long-standing research interest and information technology helps professionals collect data on demand, lead times, resources, and capacities. Using data efficiently is key for effective inventory management and the organization can choose what information to gather, buy and keep and what technology to invest in. For example, an inventory leader can use monitoring technology to track orders but if the data do not improve replenishment decisions, they are not useful. The next section examines the drivers, challenges, and types of technology adoption.

Exploring Various Information Technologies Solutions

Finished goods demand influences raw materials and components supplies and systems like MRP, DRP, or ERP are used to make finished goods from them. MRP works with JIT and Kanban models and applications, while ERP works with MRP to integrate all departmental operations. DRP uses software like Oracle, SAP, and Microsoft Dynamics (Munyaka & Yadavalli, 2022).

Enterprise Resource Planning (ERP)

MRP is a web-based method to plan raw material orders based on accurate and reliable information. It aims to keep the inventory level consistent with production needs (Hasanati et al., 2019). MRP is also a key part of ERP systems that support discrete production. It uses MPS, BOM and inventory data from ERP to calculate the required quantities and dates for finished goods and their components (Lambert et al., 2017).

Distribution requirement planning (DRP).

DRP is a technique that calculates the product quantity for each distribution point using control variables. It benefits from aligning manufacturing with facility demands and resolving inventory issues with MPS and forecasting (Magdalena & Suli, 2019).

Just-In-Time (JIT).

JIT system is based on customer satisfaction and

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
http://dx.doi.org/10.21622/IBL.2023.03.1.029

continuous improvement through waste elimination and techniques like Kaizen, 5S, etc. (Phogat & Gupta, 2019). JIT system can enhance equipment use, inventory reduction, quality improvement, space-saving, cycle time reduction, supplier relations and employee involvement. JIT is applied to three types of inventories: Raw materials, work-in-process and finished products (Azim, 2018).

Vendor managed inventory (VMI). VMI system is a cooperative technique between buyer and vendor that optimises items with trust, information visibility, lower inventory costs and improvement (Dai et al., 2017). VMI gives supplier flexibility to ensure buyers' availability and replenishments. The contracts also increase the supplier's knowledge of the buyer's demand trend. Demand visibility and autonomy delegation are key VMI success factors (van den Bogaert & van Jaarsveld, 2022).

Warehouse management system (WMS). WMS helps firms to automate and improve systems and processes related to warehousing and inventory control. It manages all activities in one or more warehouses from tracking inventory quantity to assigning it to proper locations in the storage area. It is designed to handle stock movements across warehouses and provide real-time information that enhances inventory record accuracy and management (Folinasa et al., 2022).

Radio Frequency Identification System (RFID)

RFID is a system that uses tags and readers to collect and transmit product data via radio waves (Zhang et al., 2022). RFID enhances supply chain management, logistics and inventory control efficiency and can be used in various industrial fields. It can digitise data and offer benefits like reducing human error, streamlining transactions, providing data, and solving supply chain issues (Feng et al., 2017). For example, grocery stores can use RFID for better reordering and integrate it with other systems like EDI, VMI, ECR, CPFR, etc. (Reyes et al., 2021).

Electronic Data Interchange (EDI)

EDI is a system that allows firms to share data sets about their stocks, prices, specifications, and locations using digital communication technology (Mutuvi et al., 2019). It creates connections with trade partners and replaces paper-based systems. It is the electronic sending and receiving of trading documents like invoices and sales orders that reduce data entry checks and postal delays (Wang et al., 2019).

Information Technology Adoption Drivers

Organisation Strategy

Many studies have examined the factors affecting IT adoption, focusing on the variables that influence the choice and intention to use IT. These include cost-benefit analysis, organisational innovation, experience and knowledge, employee engagement and commitments, training and development, IT infrastructure and external variables like expertise, corporate partners, vendors and customers (Zamani, 2022). Other studies have also found organisational traits as potential factors, such as strategy, organisation size, industry, information intensity, organisational culture, and technological maturity. The strategy involves cost reduction versus value-added approaches and whether organisations adopt IT to compete with others. A lack of clarity or strategy on IT adoption goals can lead to failure (Zamani, 2022). Moreover, studies suggest that organisations need to invest in IT to gain organisational skills and abilities and develop competencies (Gunasekaran et al., 2017).

Costs Management

Inventory management is vital and challenging for financial statements and requires investment in systems that can control inventory costs, such as ERP systems. IT can also help to optimize inventory-related expenses, such as storage, insurance, order, and labour costs, by using tools like RFID (Karim et al., 2018). Moreover, IT can reduce the risk of low inventories and customer dissatisfaction, which can lead to revenue loss (Ünal et al., 2023). Businesses that use information accessibility systems can also address external challenges more effectively and efficiently (Trantopoulos et al., 2017).

Long-term Collaborations

Long-term relationships with partners affect the

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
http://dx.doi.org/10.21622/IBL.2023.03.1.029

supply chain structure, which involves IT capabilities and information sharing (Farahani et al., 2019). IT also enhances coordination, collaboration, and interaction in the supply chain, which are essential for supply chain agility and performance (Kim & Chai, 2017). Moreover, IT benefits upstream interconnection by simplifying workflows, reducing transaction costs, streamlining information flows, and improving responsiveness and lead time. Furthermore, IT enables data visibility at all levels of the supply chain, which fosters alignment and adaptation among supply chain partners and improves performance (Oliveira & Handfield, 2019).

Visibility of Information

Automated operations allow supply chain professionals to focus on more significant tasks, such as processing real-time information instead of manual data collection and entry (Gezgin et al., 2017). Real-time data also enable decision-makers to act based on the current situation rather than the past, which makes them more agile and successful (Oliveira & Handfield, 2019). Moreover, information exchange reduces demand uncertainties and increases replenishment frequency with systems like VMI and continuous replenishment, which improves service level and delivery timeliness (Wang et al., 2019).

Efficiency

Information technology helps inventory managers to control and distribute inventory according to consumer needs, using an algorithm that evaluates inventory variables (Mahajan et al., 2023). IT also helps to identify the optimal timing for inventory value through information exchange in the supply chain network. Moreover, IT can reduce the bullwhip effect by improving demand forecasting and information sharing, which makes inventory more visible in real-time. IT can also assist logistics, production scheduling and procurement to decide the number of final units based on market demand (Fernando et al., 2020).

Challenges of Adopting Information Technology

Skills Competencies

IT revolution brings opportunities and challenges for organisations and managers need to adapt and leverage IT's capabilities while avoiding its risks (Chege & Wang, 2020). Effective people management is also needed to enhance employees' skills, competencies, and expertise for organisational capabilities, but learning depends on previous investments and technological growth that shortens the lifespan of skills. Moreover, adapting to technological disruptions requires unlearning outdated technologies and practices and learning new alternatives, which is difficult with existing systems and challenges the creation of a learning society (Ra et al., 2019).

Resistance to Change

The fusion of technology in the fourth industrial revolution will change people's lives and improve productivity and efficiency, but it could also increase inequality by affecting the labour market. This poses a challenge for businesses to motivate intellectual employees and avoid negative displacement by technology automation (Xu et al., 2018). Social engagement is driven by individual attitudes towards IT use (Adb Elbary et al., 2022), but businesses' rules and guidelines may override employees' opinions and preferences and cause dissatisfaction (Ajibade, 2018). Moreover, individuals assess time and effort in organisational contexts when forming opinions about IT use and environmental familiarity is a key factor in technology use (Tamilmani et al., 2021).

Cybersecurity and Data Ethics

Cybersecurity refers to the tools, regulations and procedures that protect data and resources from cyberattacks, which are more likely in the industry due to the multitude of partners and lengthy supply chains, mostly composed of smaller firms with limited IT resources (Mantha & de Soto, 2019). Cyberattacks can come from internal and external sources, such as hackers, cyberterrorists, operator errors and disgruntled employees, and they evolve rapidly and require continuous and complex risk detection and mitigation (Xu et al., 2018). IT also poses ethical challenges, such as violation of privacy, copyrights, personal and social rights, preservation of values and accountability for IT impacts. Moreover, IT increases the risk of data loss due to skilled cybercriminals or dishonest personnel who may use IT for their personal motives that harm a firm (Ugbogbo & Michael, 2016).

System Crash

Complex technologies can sometimes crash unexpectedly and there is little research on how and why systems fail and how some systems last longer or fail faster than others. System crashes are part of system evolution, but they can happen in unusual ways with a simple rule or error that affects multiple levels (Wang et al., 2019). Crashes can be hard to monitor even when the causes are known, such as bugs in software and firmware code that can be exploited by attackers. Memory corruptions or faults are a common type of problem that can lead to vulnerabilities which sometimes are silent and do not cause immediate system breakdown, but they pose a serious risk to the security and safety of embedded systems and can process incorrect data at any time (Muench et al., 2018).

Sustainability

Initial investment costs are considered before operational costs and Moore's law states that IT costs decrease while performance improves (Wang et al., 2020). However, IT competence is still vital, and businesses should develop it carefully as IT costs are falling and technological changes increase the risk of using outdated technologies. The question of whether IT capabilities can sustain organisational performance over time is also important and challenging as the rapid adoption of technologies with standardised and similar information-sharing programs makes IT-based competitive advantages short-lived. The value of having superior IT competence may not relate to better performance when IT underwent a significant revolution with innovations that increased the availability and commonality of IT, such as the Internet, outsourcing, ERP systems and computing costs (Ilmudeen, 2022).

Summary

This section summarises various IT types, such as VMI, MRP, ERP, DRP, JIT, WMS, RFID and EDI, that affect inventory replenishment and levels. The drivers to adopt IT can be internal factors, such as organisation strategy and cost management, or external factors, such as pressure and integration with partners and the desire to build long-term relationships with them through information visibility that improves operation efficiency internally and externally. This research contributes to the field of inventory management by offering practical insights and recommendations for inventory managers and IT developers who aim to improve their inventory management practices and systems with various IT solutions. It also demonstrates the significance of IT for improving supply chain management and operational performance, which is a main goal of inventory management. Furthermore, this research addresses a gap in the literature on IT adoption in inventory management by comparing multiple case studies with different IT systems and industries. It identifies the common and unique factors and challenges that influence IT adoption and provides implications for inventory managers and IT developers.

Research Methodology

Introduction

The research objectives of this study were to explore the drivers, challenges, and types of IT in inventory management. Qualitative research with in-depth interviews was the ideal approach as it could examine the information from senior employees in the industry from different perspectives and provide more insight. Hence, this research used an inductive approach as it worked well for qualitative content analysis by observing and inferring from observations and no theory is present at the beginning; instead, theories would emerge from the research (Gao & Zhang, 2019). Inductive researchers also claimed that one can rationally extrapolate the findings into all principles and that this process would confirm and validate the scientific assumptions.

Research Sampling Strategy

A qualitative sampling strategy specifies the number of observations, interviews, focused dialogues, or cases needed to verify whether the findings will

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
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provide rich information while a quantitative sampling plan includes the number of respondents, is explicitly defined. The main features of a qualitative sampling plan are respondents that are often carefully sampled with each research's sample size varying and being small, sampling would change when new questions are found during data collection and analysis, and the sample is selected based on intellectual needs rather than only on generalisability (Moser & Korstjens, 2018). Six phases need to be followed to perform sampling which includes defining the target segments, sample frame to be chosen, sample method choice, decision of significant size sample, data collection method and response evaluation (Taherdoost, 2016).

Research Approach

Qualitative research would be an ideal approach for this research topic; thus, a non-probability sampling using quota sampling technique was the most suitable technique to adopt as it ensured the overall sample has the same range of characteristics as the larger population and respondents are selected based on specified qualities (Taherdoost, 2016). Furthermore, it was implied that a sample number of one is the lowest which can be considered appropriate for some types of qualitative studies, with the possibility that a particular case study that involves one area of study could be relevant and offer insightful data (Vasileiou et al., 2018).

Interview Questions Formulation

The purpose of this research is to address three specific research objectives related to IT and inventory management. The interview questions for this research will be formulated by reviewing the literature on IT and inventory management and identifying the relevant concepts, variables, theories, and models that link the research objectives with the IT solutions and inventory management outcomes. Consequently, specific, and clear questions will be created to address each research objective, as follows:

- For RO1, the interview questions aim to explore the drivers and impacts of IT adoption on inventory management in various dimensions. They cover strategic, competitive, social, process, performance, and contextual factors that influence and affect IT adoption and usage in the organisation. They also examine how IT affects inventory management outcomes such as performance, efficiency, cost, risk, collaboration, coordination, information, forecasting, logistics, planning, and procurement.

- For RO2, the interview questions explore how IT adoption influences and affects inventory management in various dimensions. They address the drivers and impacts of IT adoption, such as strategic, competitive, social, process, performance, and contextual factors. They also investigate how IT affects inventory management outcomes, such as performance, efficiency, cost, risk, collaboration, coordination, information, forecasting, logistics, planning, and procurement.

- For RO3, the interview questions investigate the organisational and human resource challenges of IT adoption and usage in the organisation, assess the security challenges of IT adoption and usage in the organisation, and explore and measure the sustainability and reliability challenges of IT adoption and usage in the organisation, and for inventory management.

Data Collection

This research aims to analyse the use of IT in the inventory management sector; hence, the quota sampling technique of the non-probability sampling concept is used to collect data. Four respondents from different companies are selected for in-depth interviews to explore and evaluate the industry's IT use. The interviews were conducted for three weeks, from February 6 to February 19, 2023, and lasted about an hour and a half each. Consent forms are given to respondents for their approval before the interviews start. Physical interviewing is chosen over surveying because qualitative research involves a detailed analysis of individuals' experiences and issues in their situations without using predefined and standard categories of analysis. The physical face-to-face interview has advantages such as giving respondents flexibility to discuss factors based on their knowledge, allowing researchers to intervene when needed and ensuring that the respondent understands the topic being studied (Adhabi & Anozie, 2017).

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
http://dx.doi.org/10.21622/IBL.2023.03.1.029

Data Analysis

Qualitative data analysis is often argued to be hard, time-consuming, and complex without theoretical focus and is especially relevant for new researchers who lack specific guidance on how to analyse qualitative data using certain approaches. According to this, inductive techniques mainly depend on accurate assessments of actual data to derive themes and concepts, which requires alternating between data analysis and research to make logical sense of emerging notions. Additionally, thematic analysis is the method to create a theoretical model to explain an approach that exemplifies precision in qualitative research using either inductive or deductive techniques to generate rich interpretative data analysis (Azungah, 2018). Therefore, the six steps of thematic analysis are as follows:

1. Familiarization: Reading and rereading the data, taking notes, and highlighting important points to get to know it better.
2. Coding: Highlighting sections of the text and assigning them a label that summarizes what they are about.
3. Generating themes: Organizing and grouping the codes by themes, topics, ideas, and patterns of meaning that come up repeatedly in the data.
4. Reviewing themes: Evaluating the themes on two levels: how they represent the coded data and how they apply to the entire dataset.
5. Defining and naming themes: Defining each theme's core concept and organizing them into a coherent narrative that covers the whole data and giving each theme an informative and interesting name.
6. Writing up: Writing the data analysis with themes and literature, comparing, and verifying the evidence, and presenting credible reasoning to the research question.

Ethical Consideration

This research follows ethical guidelines to protect participants' rights and interests. Participants can withdraw at any time and must sign consent forms before joining the study. The research ensures participants' confidentiality and anonymity by hiding their identities and names in the data collection, analysis and publication stages. The research also respects the privacy of the interview settings and the dissemination of the results (Arifin, 2018).

Summary

The section delves into the exploration and rationale for various research techniques, with a specific focus on the qualitative techniques employed in this study. The researcher thoroughly examines and justifies the selected qualitative methods, offering valuable insights into the entire process. This encompasses an overview of the inductive approach employed, the devised sampling plan, the data collection procedures, the six steps of data analysis, as well as a comprehensive discussion on ethical considerations. The researcher aims to identify and utilize appropriate data sources, thereby providing a comprehensive understanding of the qualitative methodology employed.

Findings and Analysis

Introduction

In this section, the analysis focuses on the primary data obtained from individuals working in the supply chain industry in Singapore. The researchers conducted four semi-structured in-depth interviews to evaluate the usage of information technology in inventory management. All interviews were conducted in person, with phone audio recordings used. The data for each theme was explained, and the key points were documented in a thematic analysis table. The relevant details of the respondents are presented in the appendices section.

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
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Various Information Technologies Used

Inventory Management IT Solutions

Four respondents use ERP or DRP systems for inventory management, both common types of IT found in section two. The interviews revealed different software such as Task Hub, Power BI, AppSheet, and A2000 Clarity which were used for data analysis, visualization, and app development. The DRP system software includes SAP and Salesforce Applications. One respondent uses Task Hub, a real-time but limited and unfriendly system, and Power BI to create charts or reports for inventory decisions. Another respondent uses AppSheet to customise applications to suit functions. Some respondents use one system to manage inventory, finance, sales orders, and invoices. These systems align with section two: maintaining inventory stability according to demand. The difference is that the literature shows ERP is for the production end, but wholesalers or other organisations with inventory need this IT too. Some respondents use SAP for data input and Salesforce to order supplies and monitor orders (red = order in process, green = order completed or delivered). The others use SAP to link various departments and track everything for audit. As in section two, inventory level concerns can be resolved through DRP by proper forecasting and ordering supplies accordingly. In sum, most respondents use IT internally and do not link with suppliers.

Other Information Technology Solutions Used

Respondents used other forms of IT before the current ones, but mostly for supply chain and not inventory management. They used IT such as CRM to keep contact details, EDM to do marketing, Scala for database, and Microsoft Navision like Excel. One respondent used Manpower Management software to monitor leave and generate pay slips or payroll for human resources. Some of them previously used RPA to arrange orders by filling templates and sending them to robots. The robots opened SAP and copied data (sales orders) to SAP. Now they use RPA for inventory projects to check stock movement, such as fast-moving and slow-moving goods, for better inventory placement.

Information Technology Adoption Drivers

Organisation Strategy

Most respondents said that IT adoption is part of their business strategy and helps them stay competitive in their industry. However, some claimed that IT adoption was more of a necessity than a choice, as it helped him cope with daily tasks. The others said that IT adoption was essential for survival in the market and for achieving long-term automation goals. This shows organisation strategy as an important factor for IT adoption, which agrees with Zamani (2022). What differs is that organisation sizes or technological maturity do not matter for IT adoption. Management decides if IT is needed and executes it.

Costs Management

All respondents agreed that cost management is the most important factor for IT adoption, as it helps reduce variable costs such as storage, ordering, outdated stock, and risk of low inventories. This is consistent with Karim et al. (2018), who mentioned that IT allows inventory visibility and lower reordering frequency. Some respondents mentioned that IT also shows fast- and slow-moving consumer goods and dead stock. The others mentioned that IT helps check items to be scrapped. These are waste costs that can be eliminated or lowered.

Long-term Collaborations

Farahani et al., (2019) mentioned that IT connections and information sharing have a positive outlook on long-term relationships with vendors. Respondents agree that IT enhances relationships with vendors but only to some extent and this does not influence IT adoption.

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
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It helps retain vendors' information in the system and seize opportunity costs with vendors based on a live-tracking system. Some mentioned that they could not see the enhancing relationships between IT and vendors as the system is only for internal purposes. The other respondents utilise IT connected with some vendors and agreed that this enhances long-term relationships.

Visibility of Information

Three respondents use IT internally and mentioned no visibility of information sharing with vendors but among various departments in each organisation, enhancing their daily functions. This is a factor for IT adoption as it helps efficiency. This agrees with Gezgin et al., (2017), who mentioned that IT removes manual data collection, filtering, entry and asking for information in the workplace. IT also shows product delays and decision-makers act accordingly.

Efficiency

As presented in the literature review section, IT helped with accurate demand forecasting and real-time inventory visibility, decreasing the bullwhip effect in logistics, procurement, and production scheduling. All respondents agreed on this and considered it an important factor for IT adoption to streamline operations. The findings include reducing grey areas and over-purchasing, as IT generates figures and stock levels for planning and lowers forecast errors while keeping low inventory. One finding that contrasted with Fernando et al. (2020) was that auditing adds accountability and security to the company, as employees cannot commit fraud and can only purchase from legitimate suppliers.

Other Drivers to Adopt IT

All respondents agreed that the main drivers for IT adoption among the respondents were cost management and efficiency. Cost management involved capturing opportunity cost, analyzing buying trends, and planning for bulk purchasing before prices increase, which would lead to economies of scale. Efficiency involved managing tight deadlines with IT, reducing human errors, and eliminating manual work, which would save time and lower employee dissatisfaction. Another driver that some respondents mentioned was auditing. They said that auditing added accountability, improved company ratings to attract investors or customers, and prevented fraud.

Challenges of Information Technology Adoption

Skills Competencies

The respondents faced challenges in acquiring relevant IT skills during the implementation. According to Ra et al. (2019), skills courses and learning are essential for employee competencies. The respondents reported receiving basic training, guidelines with standard operating procedures, and training guides and tutorials. However, they found it difficult to learn the new system. Some of them attributed this to the COVID-19 pandemic, which made training harder and left some staff still incompetent despite training. Others complained that they did not receive proper training and had to figure it out themselves, even though tutorials and videos were provided. Only a few of them stated that the system was straightforward and that the training helped them pick up skills and knowledge easily and quickly.

Resistance to Change

Similar to the literature review, half of the findings indicated that employee resistance to IT use was a challenge. Some employees resigned due to the new IT implementation, even though it was adjusted and customized to suit the business functions, but they did not comply. Management made IT use mandatory by requiring monthly presentations during meetings with IT. The findings showed that resistant employees were generally experienced people with older age. On the other hand, some respondents reported no resistance as most employees were involved during the IT design and implementation. Some also reported no resistance and more of learning by trying and accepting the new system.

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
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Cybersecurity and Data Ethics

In contrast to Ugbogbo & Michael (2016), who state that IT increased vulnerability to cyberattacks and dishonest personnel may misuse information, which could be detrimental to the firm, the findings suggest otherwise. All respondents mentioned that IT was secure and had strict rules on integrity and IT protection to adhere to. No incidents of cyberattacks were reported by any of the respondents. However, one respondent mentioned a virus attack once in the ERP system that caused data loss, and another mentioned employees deleting crucial information before leaving. Both incidents were resolved by a capable IT team from backup.

System Crash

Unlike Muench et al. (2018), who mentioned that monitoring crashes might be challenging even when processes are in place and flaws in software code are bugs, the respondents did not see this as a challenge. They said that errors and bugs occurred only once or a few times a year, and the systems were stable with no crashes or breakdowns. They also said that when they faced issues such as refreshing the system page unsuccessfully due to bugs or errors, or user error due to access not being given but needed, they were all resolved quickly by a competent internal or external IT team. One finding was that the customisation of IT determined the stabilisation of IT, meaning that more customisation led to more instability.

Sustainability

The respondents had different views on the sustainability of IT capabilities over a long period, given the fast adoption of new technologies. Ilmudeen (2022) stated that this was an important and difficult issue for organizations. However, all respondents did not see this as a challenge and believed that their current IT was sustainable and useful even when new technologies emerged. They mentioned that the organization kept up with IT trends despite some restrictions in implementing them, and one respondent mentioned that one system (AppSheet) could be replaced by artificial intelligence that could also replace humans. Some respondents did not foresee any factors that could make their current system obsolete for the next five years, unless the business model changed from B2B to B2C, while others mentioned that their system would still be relevant for at least the next five years. Some also intended to move to a cloud-based system but postponed it due to the lack of investment capital.

Other IT Adoption Challenges

The respondents faced various challenges that were not covered in the literature review. One challenge was staying up to date with the latest technologies. Some respondents mentioned that their organizations were slow in digitalization and had a huge gap in IT adoption, even though their current IT was stable and sustainable, but this also meant limited benefits for their organizations. Another challenge was finding new ways to use IT to capture and analyse data, which led to investment challenges. They also faced the biggest challenge of implementing IT during the pandemic, as employees encountered errors and waited for days to rectify them, slowing down the workflow (Shokair et al., 2023). Furthermore, some respondents stated that the main challenge was identifying the needed or required IT systems and the correct IT vendor, and not knowing if IT would enhance or bring down their operations. From some respondents' perspective, IT reduced variable costs but also increased the costs associated with maintaining and implementing it. The most challenging part for them was dealing with different time zones with an outsourced IT team and waiting for a response when issues occurred.

Conclusions

Introduction

This section aims to draw meaningful conclusions based on the findings presented in section four, thereby fulfilling the research objectives outlined at the beginning of this study. It also entails a comprehensive review of the research's limitations and proposes potential avenues for improvement in future research studies. By

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synthesizing the key insights and addressing any gaps, this section contributes to a comprehensive and conclusive understanding of the research topic.

Evaluating Research Objectives

Objective 1: Various Information Technologies Used

Seven types of information technologies that were found in the research and findings showed that the ERP system is commonly used. In this system, various software for organisations to adopt and invest in include Task Hub, Power BI, AppSheet, Salesforce Application, Robotic Process Automation, A2000 Clarity, and SAP. These technologies or software work similarly depending on the customisation. Most link all departments internally and uncommon to connect with external parties such as vendors or suppliers. Except one organisation spent a lot on information technologies, linked with external parties and had a lot of customisations. Various functions of information technologies include creating charts or reports for inventory decisions, managing inventory, finance, sales orders, and invoices in one system, ordering supplies and monitoring orders. Fang & Chen (2022) said managing stock in/out by batch with decision-making may serve as a basis for enterprise groups to decide appropriately. Overall, it maintains inventory stability according to demand and allows auditing with trackable records.

The findings also showed a few more technologies for the supply chain that aid operations and inventory management. These include Customer Relationship Management software, Electronic Direct Mail, Scala, Microsoft Navision, and Manpower management software.

Objective 2: Drivers of Adopting Information Technology

Among five drivers found in the literature review: organisation strategy, costs management, long-term collaborations, visibility of information and efficiency; yet, long-term collaboration is the least important or not a driver for IT adoption. The most important drivers are cost management and efficiency. Findings showed efficiency links to organisation strategy and visibility of information. For efficiency, decision-makers check inventory status in real-time in the digital era, decreasing the bullwhip effect from production scheduling to logistics (Liu et al., 2021). It also reduced demand forecasting errors linking to the visibility of information as the system shares information with employees from various departments, removing manual data collection and entry. These determine organisation strategy whether IT adoption is to cope with daily tasks or be competitive with trends.
When considering IT adoption, cost management matters. It includes variable costs such as storage costs, ordering costs, outdated stock, and risk of low inventories and how technologies help organisations understand dead stock and scrapped stock to eliminate waste costs. Also, implementation means investment capital. Organisations need to learn how to incorporate and anticipate competencies from IT measurement thus, a balanced procedure highlights IT benefit in monitoring and learning from business activities and easier for management to show IT value contributions (Luftman et al., 2017).

The findings showed that the respondents' opinions, long-term collaborations do not affect IT adoption even though it enhances relationships with vendors to an extent. Contact details will not be lost as in the system and able to seize opportunity costs with vendors based on a live-tracking system.

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Objective 3: Challenges of Adopting Information Technology

Out of the five challenges found in the literature review: skills competencies, resistance to change, cybersecurity and data ethics, system crash and sustainability; skills competencies and resistance to change are most challenging. Respondents' insights, most employees lack relevant IT skills upon implementation and despite training or guidelines provided, it is tough as some are not competent. The exception is straightforward and easy-to-use technologies with employees' participation in the design stage leading to lesser resistance.

The reason why resistance to change is a challenge was that experienced employees are generally older, not complying as they do not see the need in using technologies for job scopes. Some resigned because of this, leading to a higher turnover rate. Organisations had no choice but to make IT use mandatory leading to more dissatisfied employees. Henderson and Venkatraman's (1993) groundbreaking theoretical model pointed out that in achieving alignment of implementation, IT and business management play various roles and shoulder various important duties (Luftman et al., 2017). Cybersecurity and data ethics as well as system crash were not a challenge if organisations have strong IT teams and vendors who provide stable systems and lesser customisation that help decrease unstable systems or breakdowns. Additionally, strict rules on integrity and IT protection prevent employees from misusing information. Generally, with correct IT adoption, organisations see the sustainability of current ones and do not foresee what could make them obsolete for the next five years unless the business model changes. Lastly, other challenges include staying contemporary as organisations remain falling behind in digital transformation, choosing the right system and vendor for organisations, as well as expenses of implementation and maintenance.

Research Limitations

While this research has made significant contributions to the understanding of the use of information technology in inventory management, it is essential to acknowledge its inherent limitations. Firstly, due to the absence of prior studies specifically focused on this topic, the researcher had to rely on information gathered from recent reputable papers to strengthen the study's objectives and address its challenges. While efforts were made to ensure the reliability and relevance of these sources, the lack of existing literature on the subject may have impacted the comprehensiveness of the research. Secondly, despite Singapore's significant presence in the supply chain industry, there were limited avenues available for direct engagement with organizations. This constraint necessitated modifications to the sampling strategy and sample size, as access to potential participants was restricted. As a result, the research had to adapt to these limitations, potentially impacting the representation and diversity of perspectives within the study. Furthermore, the research only explores five factors for each research objective, and the sample size consists of four respondents from four different companies. This limited sample size, and the focused scope of the research may have restricted the breadth of topics covered, potentially leaving some important aspects unaddressed.

To address these limitations, future research should strive to expand the literature base on the use of information technology in inventory management. Additionally, efforts should be made to enhance access to a wider range of organizations within the supply chain industry to obtain a more diverse and comprehensive sample. Finally, future studies could consider broadening the scope of factors and increasing the sample size to further explore the complexities and nuances of this research topic.

Recommendations for Future Research

To enhance the strength and comprehensiveness of the data collection process, future research could consider expanding the number of respondents from different organizations. Increasing the sample size from four to perhaps ten or twenty would provide a more robust foundation for qualitative research. Additionally, further investigations can be conducted to identify potential factors that were not covered in this study. This could involve expanding the research objectives or considering additional factors that may influence the use of information technology in inventory management. Moreover, to augment the research approach, a larger sample size could be explored within each position or role to provide deeper insights and a more comprehensive understanding. This could potentially involve incorporating quantitative research methods alongside the qualitative approach. By integrating quantitative data analysis, the research could attain a more holistic overview of the application and impact of information technology within the inventory management industry. By addressing these areas for future research, scholars can delve further into the complexities and dynamics of the topic, contributing to a more comprehensive body of knowledge on the use of information technology in inventory management.

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Volume 3, Issue 2, December 2023 - ISSN 2735-5969
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Appendix

Research Interview Questions

RO1: To outline the various types of information technology used for inventory management.

1. What kind of information technology (IT) does your organisation use?
2. Please provide further details regarding the use of the relevant IT.
3. What other kinds of IT have you used before the current one? – Provide a brief description of how it works.

RO2: To explore the drivers of adopting information technology in inventory management.

1. Does your organisation use IT as a business strategy or only to stay competitive with other businesses using IT?
2. Did using IT reduce the variable expenses associated with inventory? (Such as storage costs, insurance costs, ordering costs, outdated stock, and risk of low inventories)
3. Did the use of IT improve long-term relationships with vendors? – Is this a factor in the adoption of IT?
4. How big of an impact did IT have on the visibility of information sharing? - Did it enhance replenishment frequency and streamline operations?
5. How does IT enhance demand forecasting, logistics, production planning and procurement?
6. What are the other IT adoption factors in your organisation?

RO3: To identify the challenges of adopting information technology.

1. Do the majority of employees have the necessary IT skills? – (If no, how did the organisation address the issue? Is training provided?)
2. Are there any employees who have resisted using IT since it was implemented? - And how did the company prepare the staff for the changeover? (For example, letting them know ahead or allowing them to participate during implementation, etc.)
3. Have you come across any cyberattacks or dishonest employees who have used the organisation's information inappropriately thus far? – How was it resolved?
4. Do system crashes occur regularly? – When they do, how do you cope?
5. Do you think the existing technology can sustain and still be useful while other new ones emerge? – (how do you view the sustainability of the current IT?)
6. What other challenges does your organisation face while using IT?

Investigating Challenges and Opportunities of Applying Blockchain Technology to Reduce Agrifood Loss

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Abstract

***Purpose**: Agriculture plays a significant role in the Egyptian economy, accounting for 11.3 percent of the nation's gross domestic product. The agricultural industry constitutes 28 percent of the workforce, with agriculture-related employment in Upper Egypt surpassing 55 percent. However, the Egyptian agrifood sector faces many challenges, such as poor post-harvest infrastructure, exposure to high temperatures, and poor handling practices. Moreover, In response to these challenges, this research aims to investigate the prospective challenges and opportunities of applying blockchain to reduce food waste, improve agrifood security, and enhance food supply chain traceability in the Egyptian agrifood industry. The methodologies employed in this study were instrumental in achieving the study objectives, which were twofold: (1) To identify the main challenges and factors that influence the adoption of blockchain technology in the agrifood industry, drawing on existing literature, and (2) To determine the relative significance of potential barriers that may arise during the implementation of blockchain technology in the Egyptian agrifood sector.*

***Design/Methodology/Approach:** The study relies mainly on the Technology Acceptance Model (TAM) theory. Moreover, the investigation was conducted using a quantitative research design, first tracing the literature to identify issues related to the adoption of blockchain technology in the agrifood industry. Additionally, a questionnaire-based methodology was used to gather data. The sample consisted of 37 participants, who were conveniently picked from seven agricultural organizations in Egypt.*

***Findings:** The findings give a full comprehension of the obstacles associated with the use of blockchain technology in the Egyptian agrifood industry which are the hesitancy of companies to disclose sensitive information, the lack of regulations in Egypt governing the utilization of blockchain technology, apprehension regarding potential job losses, concerns about the potential disruption of existing procedures, and a degree of uncertainty among certain firms regarding the complete potential and capabilities of blockchain technology. On the other hand, the potential opportunities associated with reducing agrifood loss encompass the enhancement of traceability within the agrifood supply chain, the promotion of collaborative efforts, and the improvement of operational efficiency.*

***Research Implications/Limitations:** This study contributes to the existing body of literature by exploring the potential of blockchain technology in improving agrifood security and mitigating agrifood loss in Egypt as a developing country. However, there is a noticeable lack of scholarly study about the use of Blockchain technology in developing countries. Also, blockchain technology still has some challenges and limits that need to be resolved. This calls for more research and study.*

Practical Implications/Limitations: The findings of this study may provide agrifood managers, blockchain technology service providers, and governmental entities with useful insights that can be used in the development *of effective strategies and regulations for the successful application of blockchain technologies within the Egyptian agrifood sector, with the end goal of reducing agrifood loss. However, this has yet to be proven and is just limited to the literature.*

Originality: *The current food security issue in Egypt presents a significant risk to the country's economy. The demand for food is increasing, and food losses and waste (FLW) in Egypt are particularly significant, especially in relation to perishable goods. In that region, it is estimated that the yearly percentage of fruit and vegetable food loss and waste (FLW) amounts to around 45-55% of the total output according to research conducted by the Food and Agriculture Organization (FAO). Furthermore, there is a notable impact on the quality of these products. Food loss due to poor harvesting processes and inadequate post-harvest management practices is one issue leading to agrifood losses. Accordingly, this study tests the potential challenges and opportunities associated with the use of blockchain technology in the agrifood sector of Egypt aiming to reduce agrifood loss and enhance food security. Additionally, this study is the first of its kind to comprehensively examine the barriers and facilitators of blockchain adoption in Egypt.*

Keywords: *agrifood supply chain, distributed ledger technology, food security, traceability.*

Introduction

Food scarcity is now seen as a significant global problem. In 2022, an estimated 9.2% of the global population experienced food insecurity, marking an increase from the 7.9% recorded in 2019. In the year 2022, a significant proportion of the world population, namely 29.6%, including almost 2.4 billion individuals, experienced either moderate or severe food insecurity. Among this group, 11.3% faced the severest type of food insecurity[1]. Locally, Food security is a fundamental concern within Egypt's 2030 Vision, seen as a matter of national security. The country is actively engaged in efforts to increase agricultural land, decrease reliance on imports, and develop strategies to mitigate the impacts of climate change.

There are many factors contributing to food insecurity in Egypt, including a rapidly rising population, the impacts of climate change, limited access to water resources, and the issue of food loss and waste. In the past decade, the issue of food loss and waste (FLW) has received exponentially more attention. Concerning food loss and waste in the agriculture sector, the Food and Agriculture Organization of the United Nations (FAO, 2019) estimates that more than 15% of food produced for human sustenance is lost or squandered prior to reaching the retail stage of the food supply chain. Consequently, one of the United Nations' sustainable development objectives aims to reduce food waste per capita at retail stages by 50 percent by 2030 (Wunderlich, 2021). Moreover, according to a FAO study conducted in 2019, food loss and waste (FLW) along food value chains in the Near East and North Africa (NENA) are estimated to reach 250 kg per person and more than USD 60 billion annually. In addition, Nicastro & Carillo (2021) reported that one-third of nutritious food, or approximately 1.3 billion metric tons, is lost or squandered annually along the food supply chain.

In Egypt, it has been reported that the yearly output of agricultural waste amounts to around 30-35 million tons (Kamel, & El Bilali, 2022). Furthermore, it is anticipated that each individual in the country generates around 250 kg of food waste per year, positioning Egypt as a significant contributor to the global food waste dilemma.[2] Furthermore, food waste as well as food loss contribute to increased CO_2 emissions, which have a negative impact on the environment. The Food and Agriculture Organization estimated in 2016 that about 3.3 gigatons of CO_2 were emitted globally due to food that was produced but not consumed. In addition, food waste and loss have an impact on land use. Globally, approximately 1.4 billion hectares of land were wasted in 2007 by producing crops that were not consumed. Locally, food loss and waste remain significant in Egypt, especially for perishable commodities such as fruits and vegetables, with annual losses estimated to range between 45% and 55% of total output (FAO, 2019).

One of the potential solutions that has been suggested to address the problem of food loss is the use of blockchain technology. The blockchain is a component of Distributed Ledger Technology (DLT), which is a software mechanism that relies on a shared database accessible to all members. In a Blockchain, each transaction executed between two participants is meticulously documented in a permanent manner. These enduring documents are referred to as blocks. Furthermore, any computer engaged in the processing of Blockchain transactions is often denoted as a node. An additional bonus of these technologies is that the exchanged data is encrypted, providing an extra layer of protection. It is difficult to implement a modification to any one block without the approval

1 Food Security | Rising Food Insecurity in 2023 (worldbank.org)

2 FAO in Egypt | Food and Agriculture Organization of the United Nations

of the participants as a whole (Patelli & Mandrioli, 2020). Therefore, the four major characteristics of the dispersed blockchain are its decentralization, security, immutability, and transparency. The potential of blockchain technology in mitigating food loss is significant since it enables enhanced eco-efficiency via digitization and connection with the Internet of Things (IoT). Additionally, it addresses the issue of asymmetric information by promoting transparency and eliminating reliance on middlemen (Pakseresht et al., 2022). Moreover, Facchini et al. (2022) added that the use of blockchain technology has the potential to enhance the levels of transparency and traceability in the agricultural and food industry. This may be achieved by using blockchain for various agrifood items, including crops, animals, and processed foods. The use of blockchain technology has the potential to mitigate instances of food fraud, verify the legitimacy of products, and enhance consumer satisfaction. Additionally, it has the potential to enhance the effectiveness and long-term viability of agrifood systems via waste reduction, quality enhancement, and transaction facilitation.

According to the researchers' knowledge, no research has been undertaken to assess the primary challenges associated with the adoption of blockchain technology in the agricultural sector in Egypt as a developing country. Therefore, this research addressed the existing gap by evaluating the primary challenges that hinder the adoption of blockchain technology, particularly in Egypt. Moreover, to prioritizing the potential barriers that may arise during the implementation of blockchain technology in the Egyptian agrifood sector based on their level of importance.

Literature Review

Agrifood Loss and Waste

Sometimes, the terms "food loss" and "food waste" are used similarly, however, they refer to losses at different stages in the food supply chain. The food supply chain is made up of the phases that food passes through on its way from agricultural production to consumption. These phases are agricultural production which is harvest, post-harvest handling and storage, and processing. Food loss occurs when food is spilled or spoils before it is turned into a finished product or reaches the final consumer. Food waste, on the other side, is food that is fit to eat but is wasted before being consumed, either by the retailer or by the end customer (Kennard, 2019). Moreover, there are two types of food loss which are quantitative loss and qualitative loss. Quantitative food loss refers to the loss that occurs as a result of weight loss, crop accidental spills, microbial attacks, and insect attack. While the qualititive food loss occurs as a result of nutrient loss, unpleasant changes in taste and texture, the presence of excreta such as birds and rodents, and mycotoxin contamination.

Food loss and waste are mostly seen at various points of the food supply chain, including both developed and developing nations. In developed nations, a significant portion of food is wasted during the retail and consumer phases, but in economically weak nations, food is often lost at the manufacturing or processing stages of the supply chain prior to its final consumption. There are many causes for agriculture food loss like poor harvesting techniques. For example, harvesting tomatoes late in the season or badly maintained mechanical harvester for wheat, etc. poor handling procedures and exposure to high temperatures and sunlight; lack of marketing systems resulting in food products being stuck at wholesale), lack of processing equipment and factories and shortcomings in policy and regulatory frameworks cause losses during the production, handling, processing, and distribution of food. Figure 1 shows the different causes of food loss in the agriculture supply chain´s distinct stages.

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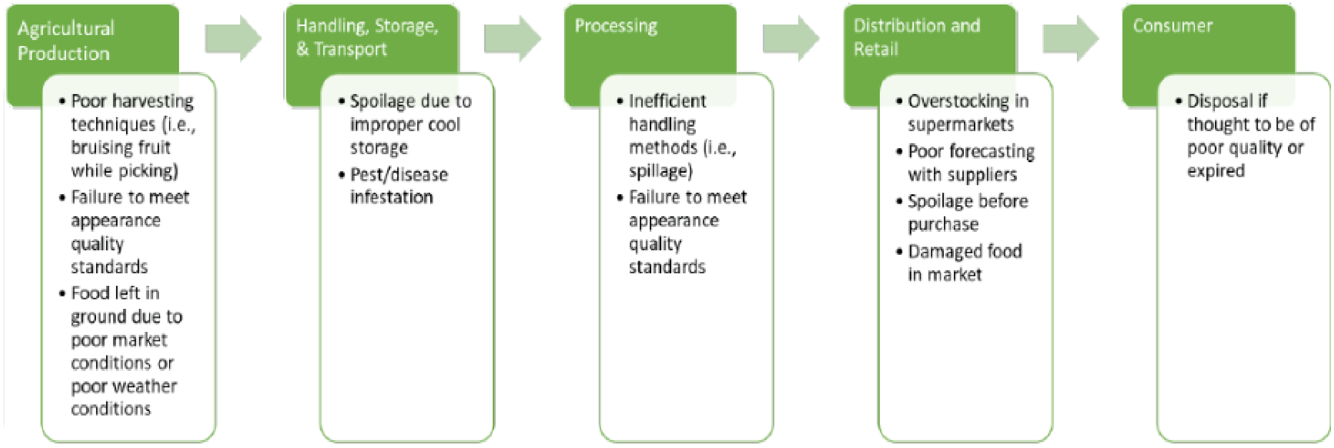

Figure 1. Causes of Agriculture food loss

Source: (Kennard , 2019)

Egyptian Agrifood Loss and Waste

The agricultural industry has significant economic importance in Egypt, serving as the primary livelihood for over 55% of the population. Moreover, the agricultural industry constitutes around 17% of the gross domestic product (GDP) of the country and accounts for approximately 20% of foreign currency earnings (Kamel & El Bilali, 2022). Moreover, several factors contribute to the occurrence of agrifood loss. The task of monitoring the specific areas or practices responsible for agricultural food losses and ensuring traceability throughout the whole supply chain network is a significant challenge. Nevertheless, Egypt's population is expected to rise quickly, reaching 150 million people by the year 2050. Due to this fast increase, there is a shortage of fresh water supplies and land suitable for agricultural practices. Even though Egypt's food demands are growing, there is still a significant rate of food loss and waste, especially for perishable items like fruits and vegetables, where the yearly estimated loss ranges from 45% to 55% of total output (FAO, 2019). For instance, Egypt is considered the world's largest tomato producer. The area cultivated with tomatoes was estimated to be 469,000 feddans in 2015, accounting for 32% of the total area cultivated with vegetables in Egypt. The following table illustrates the development of tomato production, consumption, and loss in Egypt from the year 2001 to 2015.

Table 1: Development of Tomato Production, Consumption and Loss in Egypt for the Period 2001-2015

Annex 1 – Development of tomato production in Egypt during the period 2001

Year	Tomato total area (1000 feddans)	Yield Ton/ feddan	Production (1000 Ton)	Consumption (1000 Ton)	Loss (1000 Ton)	Quantity Exported (1000 Ton)
2001	430.2	14.7	6329	6106	679	5
2002	454.9	14.9	6778	6106	679	5
2003	459.2	15.6	7140	6439	715	4
2004	464.4	16.4	7641	6919	769	7
2005	495.3	16.9	8391	7410	1010	22
2006	524.1	16.4	8576	7361	1299	8
2007	537.2	16.1	8639	6913	2304	59
2008	571.8	16.1	9204	6913	2304	59
2009	599.6	17.1	10279	7659	2553	142
2010	515.2	16.6	8545	6344	2115	142
2011	505.8	15.9	8054	6069	2023	81
2012	515.2	16.6	8571	6399	2133	124
2013	488.7	16.9	8269	5669	2429	612
2014	509.6	16.2	8265	5650	2422	245
2015	468.5	16.5	7727	5650	2422	91.5
Average	502.6	16.2	8161	6507	1723	107

Source: (Food Loss and Waste | FAO in Egypt | Food and Agriculture Organization of the United Nations., 2021)

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From Table 1, it becomes obvious how tomato losses are increasing from one year to another starting from 679000 tons in 2001 till it reached 2422000 tons in 2015. Some of the losses are qualitative and are due to poor agriculture practices like fertilization and irrigation while the others are quantitative caused by bacterial spot, insect injuries, and fruit worms.

Moreover, Figure 2 represents the percentage of losses according to a loss assessment study conducted in Sharqia. and Nubaria farms in the North of Egypt in 2017 (FAO, 2021). These places were chosen because they have the biggest yield volume and cultivated area. Indeed, Nubaria produces 20% of Egypt's tomatoes, while Sharqia produces over 11%. The assessment revealed that 53% of the total tomato production is undamaged, while 35% of the production is quantitative loss and the other 12% is qualitative loss which means Egypt loses 47% of the tomato value chain at the farm level, 59% at the wholesale stage, and 46% at the retail stage (FAO, 2021).

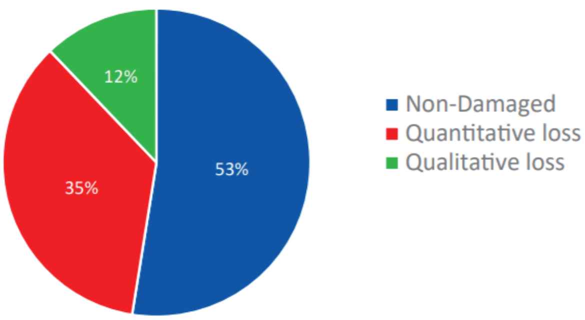

Figure 2. Percentage of losses in tomatoes sampled at farm-level Sharqia and Nubaria in 2017.

Source: (Food Loss and Waste | FAO in Egypt | Food and Agriculture Organization of the United Nations, 2021).

Additionally, the investigation also unveiled the subsequent factors contributing to the loss of tomatoes. The reasons may be categorised into two main groups: causes associated with agricultural practises, and causes associated with logistics and regulations.

- Poor post-harvest infrastructure and logistic support result in significant quantitative and qualitative losses.
- The inability of producers to plan for crop quality is hampered by a lack of control over the quality of inputs and suppliers.
- High fruit temperatures increase the rate of respiration and, as a result, the rate of deterioration and water loss increases.
- There is a lack of knowledge and capacity regarding good post-harvest practices and loss reduction.
- Tools/machinery/technologies that are ineffective or non-existent.
- Weak regulations governing the quality of local and/or imported inputs.
- Physical damage because of direct sun exposure.
- Overloaded transportation trucks, and lack of sorting and grading operations.

Blockchain Technology

Blockchain technology is gaining popularity in transportation and logistics because to its ability to create secure digital contracts and improve supply chain efficiency and transparency (Hanafy, 2021). The blockchain concept revolves around providing users with a safe and trusted platform that allows the interchange of services and transactions over a distributed network. Awwad (2018) described blockchain technology as a "chain of records or information which stored in the forms of blocks which are controlled by no single authority and once an information is stored on a blockchain, it is extremely difficult to change or delete it, as it works on the concept of decentralized database that exists on several computers and is identical in every copy." Furthermore, Elisa et al. (2019) described blockchain technology as a decentralized peer-to-peer (P2P) network that keeps track of a continuously increasing shared database (ledger) that runs on the Internet. The transactions are linked to form a "block" of records, hence it was named "blockchain." Each blockchain network participant has a pair of private and public keys for signing and verifying transactions.

Blockchain technology is currently being used in a range of financial industries, such as business services, futures markets, and financial activities. Blockchain is intended to play a key role in the global economy's long-term sustainability, benefiting customers, the current banking system, and society as a whole.

Song et al. (2019) said that blockchain technology developed from being used only in the tracking process in the supply chain management to being applied also in many functions in the supply chain management process like quality assurance, logistics, inventory management, and forecasting. Also, it is very important for businesses to rely on accurate, on-time information about the inventory status, and in-transit movements of material and products to be able to take the right decisions regarding the operations inside the supply chain. Information and Communications technology helped businesses to have these types of information, analyze them and take corrective actions accordingly.

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Blockchain and Supply Chain Management

In recent years, technological advancements have played a significant influence in altering the rules of business. The supply chain is a complicated network of activities that include several phases to meet customer needs and minimize logistical costs (Fatouh et al, 2022). Hence, there have been dramatic modifications in the manufacturing of items and their transportation to the end consumer since the industry 4.0 revolution took place. Each industry is affected by technological transformations, and businesses are included in this fast-paced change. Although this shift affects every industry, the logistics industry is one of the most affected sectors.

Tian (2016) described a supply chain as a group of organizations that work together to improve their strategic positioning and operational efficiency. Also, he added that all of these firms which work to ensure the basic principles that make up supply chain management are constructed as efficiently as possible to achieve the following :

- To reduce operating expenses,
- To maintain production quality,
- To limit inventory costs/losses,
- To have trustworthy suppliers and continue the activity,
- To ensure continuity in goods/services and information within the chains,
- To maintain strong relationships with other supply chain members, and
- To enhance enterprise competitiveness.

Nowadays, blockchain technology plays a vital role in logistics and supply chain management by enabling a traceability system to track products in each stage throughout the whole supply chain from the product's origin to its final destination. The most significant aspect that distinguishes blockchain-based technologies from other technologies is that they use a unique algorithm that is not linked to any central authority. As a result, this technology makes a major impact in ensuring that supply chain members receive timely, secure, and accurate information. It gives substantial advantages to organizations, such as the transparency of the activities conducted, this is by reducing the costs and time that arise in the supply chain (Kaya & Turgut, 2019). Moreover, El-Kady and Samrat (2021) stated that Blockchain technology has an ability to transform supply chain management (SCM).

The use of developing technology has become the solution such as block-chain as it can provide firms with greater convenience in improving business value throughout their supply chain in a rapidly digitalized world. Blockchain technology has been on the supply chain's agenda, and it is now being implemented in real systems. Large firms like Maersk and IBM have been working on new blockchain technologies to guarantee end-to-end transparency. For example, using smart sensors can assist businesses in gathering information about their supply chains as they travel throughout the world. Smart sensors are said to be used by several major supply chain organizations to track commodities. As a result, the number of these sensors is predicted to quickly increase shortly. With such a large number of sensors, there will be a vast amount of data to collect and evaluate. Blockchain technology has the potential to change supply chains and networks in ways that are both efficient and secure (Caro et al., 2028).

Drivers of Adopting Blockchain Technology in the Agrifood Supply Chain

This section discusses the motivations for Blockchain technology implementation in the food supply chain.

1. Sustainability and transparency of traceability management: according to Lin et al. (2019), traceability can be defined as the ability to locate an animal, commodity, food product, or component and follow its history in the supply chain forward (from origin to consumer) or backward (from consumer to origin). It demonstrates proof of sustainability compliance and prevents food fraud and losses, resulting in improved food security and reducing food contamination situations. End-to-end traceability is possible with blockchain technology. It is capable of meeting the standards for tracing items from farmers to customers. At each stage of the manufacturing process, traceability information such as agricultural origins, lot numbers, quarantine dates, factory and processing details, transportation details, storage data (storage temperature, humidity, gas, time, and operator), and shelf-life could be recorded into the blockchain (Kshteri, 2018).
2. Improvement of supply chain collaboration and trust: smart contracts help in self-executing and digitally verified computer protocols that are fully secure due to data encryption. Thus, it aids in the efficient operation of agribusiness and it is also useful in crop insurance to ensure long-term food security (Kamble et al., 2020).
3. Certifications of agri-products and process: because the data are timestamped and cannot be manipulated, blockchain technology certifications are completely secure. Hence, it promotes the expansion of sustainable food

security practices (Chang et al., 2019).

4. Reducing product waste and economic loss. the use of a blockchain-based traceability system can provide trustworthy data at each point of the traceability chain, resulting in a more accurate shelf life of food goods and less economic loss and waste (Mohanta et al., 2018).

Examples of Applications of Blockchain Technology in Agricultural Supply Chain

1. Blockchain in tomatoes supply chain management.

In 2022 more than 300 agricultural enterprises in Italy have used (VeChain's) blockchain. The experimental initiative known as "Tomato Blockchain" was just established by the Italian National Association of Fruit and Vegetables. This project endeavors to use blockchain technology in order to enhance the production of high-quality tomatoes. The primary objectives include ensuring traceability of the tomatoes, verifying their health attributes and, minimizing post-harvest losses[3].The first trials of the project have shown positive outcomes. This method ensured the production of premium-quality tomatoes in Italy. In addition, the VeChain blockchain aims to ensure the origin of tomatoes from farms that adhere to prescribed standards and mitigate losses.

2. Block-chain in rice supply chain management.

In India Kumar & Iyengar (2017) recommended in their study adopting blockchain to develop a system that allows for full traceability to address food theft and seeks to offer a complete history of the rice supply chain throughout all five stages (production, purchasing, processing, distribution, and retailing).

a) In the production stage: the rice is packaged in bags with tags which are then recorded into the blockchain.

b) The purchasing stage: the digital profile of the product is updated at the purchasing hub by providing data on the warehouse and transportation of rice paddies from farmers to reputable rice processing enterprises.

c) In the processing stage: rice processing enterprises will transform rice grains into rice after receiving them. Then the digital profile of the product is updated again and stores information about the product's processing phases, such as washing, peeling, storing, and packaging.

d) In the distribution stage: after receiving shipments of rice from rice processing firms, distributors regularly update information about the quality, warehousing, transportation, and distribution on blockchain at predetermined intervals, allowing it to keep track of all distributors' activities while selling rice to retailers.

e) And finally in the retailing stage: when shops receive rice packets, they can almost get all of the information they need simply by scanning the barcodes on the rice packages. Since all of the information about rice is recorded in its digital profile on the blockchain, then anyone with blockchain-enabled software may access all of the details and audit all of the activities associated with a specific rice supply chain.

Challenges and Opportunities of Adopting Blockchain Technology

The advantages and disadvantages of adopting blockchain technology in the agrifood sector and other industries have been covered in a number of prior studies. The researcher will illustrate previous studies that stated those advantages and limitations in Table 2, along with the methodological type employed in each study.

3 Italy puts tomatoes on the blockchain - Tomato News

Table 2: Challenges and Opportunities of the Adoption of Blockchain Technology

No.	Author & Year	Country	Sector	Challenges	Opportunities	Method
1.	(Feng, 2016)	China	Agrifood	High investment costs as the cost of RFID tags is expensive.	This tracking system might enable information identification, tracing, and monitoring across the entire supply chain, as well as providing a secure, visible, and traceable platform for all agrifood supply chain participants.	The authors of this paper first looked at how RFID (Radio-Frequency Identification) and blockchain technology are being used and developed, then analyzed the benefits and drawbacks of using RFID and blockchain technology to build an agrifood supply chain tracking system, and finally illustrated the system's construction process.
2.	(Kamilaris et al., 2019)	China and United States of America	Agriculture and food supply chain	Requires high investment and lack of workforce expertise.	Enhance foood security, reduce agrifood loss and enhance traceability and effeciency.	This research examines current active projects and efforts, analysing their overall ramifications, problems, and possibilities, while adopting a critical perspective on the maturity of these endeavours.

3.	(Tan et al., 2018)	United Stated of America	Food	Complete coordination and collaboration between supply chain partners to achieve full trust and a huge investment in blockchain adoption could be a major roadblock for organizations.	Food safety risks are reduced, supply chain efficiency is improved, collaboration is accelerated, and customer satisfaction is enhanced.	Case study on Walmart.
4.	(Zhao et al., 2019)	China and India	Agrifood	Storage capacity, privacy breaches, high cost and regulation issues, speed issues, and a lack of expertise are among the six challenges mentioned.	Blockchain improves agrifood value chain management in four key areas: traceability, information security, manufacturing, and sustainable water management.	From a holistic viewpoint, this paper used systematic literature network analysis to examine blockchain technology, including the latest advancements, primary applications in the agrifood value chain and obstacles.
5.	(Ray et al., 2019)	China, United Stated of America	Food	Infrastructure and network: Blockchain operates on a robust internet-connected platform that is supported by the essential IT infrastructure, which can be difficult for developing countries to implement. Moreover, Implementing blockchain technology can improve supply chain transparency and traceability. However, trust must exist between supply chain partners for them to be willing to share their data.	Increase the food supply chain's traceability, reduce paperwork, improvements in chain visibility and adherence to safety standards.	This paper followed a quantitive approach by conducting a questionnaire survey for collecting data from the participants where they have to rate the questions based on a Likert scale ranging from 1 to 5.
6.	(Azzi et al., 2019)	Switzerland	Retailing	Handling massive amounts of data without affecting blockchain performance, using a dual storage system, building a secure and dependable tracking system, and trying to fill the security flaws detected in the communication protocol.	Improving end-to-end tracking transparency, accuracy, visibility, and goods compliance with international standards to build trust between both the producer and the consumer. Lowering administrative and paperwork expenses. Fraud and counterfeit items are being substantially reduced. Streamlining the origin tracking process. Managing a product recall in a timely manner.	The researchers have adopted the theory built based on case studies with companies strat adopting partially or full blockchain system as a research strategy.
7.	(wang et al., 2019)	China	Supply chain management	Many businesses are still confused about blockchain capabilities or advantages. Issues regarding culture, procedure, governance, partnership, expenses, privacy, legality, and security.	Enhancing supply chain visibility, enables operational enhancementsand and assists in the secure sharing of information and the establishment of trust.	Sensemaking theory based on 14 interviews conducted with supply chain experts.

8.	(Feng et al., 2020)	China	Food	Achieving full trust, all partners must work together and regulatory authorities are in charge of establishing consumer data protection rules.	The data stored in a blockchain-based traceability system are more reliable and more reliable shelf life of food items resulting in reduced economic loss and food waste.	Firstly, this study undertakes a comprehensive review of the literature to better understand the properties of blockchain technology. Secondly, this paper presented an architecture design approach, as well as appropriateness and sustainability evaluations of blockchain-based food traceability systems, based on a literature review.
9.	(Dutta et al., 2020)	China, India & the United States of America.	Food sector	Data privacy and security remain a source of conflict, A lack of understanding of the new technology, Since this is a new technology, there are not many examples of its adoption, There is a fear that implementing blockchain may result in job losses.	Increased transparency, trust, and security, efficient processes, less waste, and help in the elimination of food contamination.	This study used a systematic literature review with a total of 178 publications in the field related to the usage of blockchain integration in SC operations.
10.	(Rejeb et al., 2020)	China, India, the United States of America.	Food	Scalability is a crucial challenge because if the number of transactions grows dramatically, the system may become inefficient. Moreover, the blockchain could be vulnerable to a variety of security concerns, including a mining attack, putting food companies in danger of losing data and revenue.	Boost consumer trust in food product quality, safety, and origins, as well as data and information consistency.	The researchers conducted a systematic literature review (SLR) to find, analyze, and understand research and advances relevant to the implementation of blockchain technology in the food supply chain.
11.	(Osei et al., 2021)	United Kingdom	Agrifood	Firms' lack of understanding of blockchain technology and the public's lack of awareness about the technology, Worry about existing processes being disrupted, and Companies are hesitant to share sensitive information.	Increased information flow speed is something that people are interested in, and Consumers are curious to know more about the food they consume.	Semi-structured interviews and focus groups were conducted with managers of fruit and vegetable companies and final consumers.
12.	(Etemadi et al., 2021)		Cyber supply chain risk management	Scalability/bandwidth issues, lack of interoperability and standardisation, concerns about privacy and information disclosure, inadequate user experience, malicious attacks, criminal activity, and lack of trust	Increased transparency, trust, and traceability and a database that is resistant to tampering.	This study utilized the interpretive structural modeling (ISM) technique to construct a hierarchical model, aiming to examine the contextual associations among the identified challenges regarding the adoption of blockchain technology in the domain of cyber supply chain risk management.
13.	(Vu et al., 2021).	China	Food	Lack of knowledge and expertise, high cost of implementation, and scalability.	Traceability, enahncement in food quality and safety, increase customer satisfaction, reducing food loss.	A comprehensive review of the literature and the chronological range of the search included the period from 2009 to June 2020.

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
http://dx.doi.org/10.21622/IBL.2023.03.1.048

14.	(Srivastava & Dashora, 2022)	China, India, the United States of America.	Agrifood	Security, scalability, and privacy, absence of adequate skills and training among individuals, rural areas often encounter limitations, such as the availability of low-bandwidth Internet connectivity, absence of standards and norms for the implementation of blockchain, and absence of regulatory measures.	Blockchain technology offers a durable and immutable database that facilitates the recording of every transaction, the utilization of blockchain technology facilitates the implementation of traceability, allowing participants to delineate the complete life cycle of a product, starting from its origin and extending to its ultimate conclusion.	A comprehensive review of the literature was conducted using the Scopus, Emerald, and Web of Science databases, encompassing publications from the period of 2016 to June 2021.
15.	(Vern P. et al., 2023)	India	Agrifood	Lack of familiarity with technology, lack of regulations, high capital cost, and scalability.	The implementation of blockchain technology has resulted in improved levels of transparency, reliability, and information accuracy within agrifood supply chains.	The study utilized an integrated literature review methodology and sought expert opinions to investigate the significant barriers. The barriers were assessed using the hybrid fuzzy-based decision-making trial and evaluation laboratory (Fuzzy-DEMATEL) approach to analyze their interrelationships and categorizes them into cause-and-effect groups.

Based on reviewing the literature that encompasses 15 research papers published between 2016 and the present, these studies examine the challenges and opportunities associated with the implementation of blockchain technology in various countries, including the United States of America, China, Italy, India and the United Kingdom. Furthermore, they explore the application of blockchain technology in diverse sectors such as supply chain management, food, and the agrifood industry. Various methodological approaches are utilized in each study to analyze their data. The methodologies used in these studies include systematic literature analysis, the collection of real case studies, the quantitative approach of distributing questionnaires or surveys to gather data from participants, and the qualitative approach of conducting interviews with experts in the respective fields. It has become evident that there are shared potential and obstacles in the use of blockchain technology across several sectors, in developed and developing countries with particular relevance to the agrifood industry. Accordingly, this study applied the quantitative approach by distributing questionnaires to test the main challenges that could be faced by agriculture companies.

Technology Acceptance Model

This research uses the Technology Acceptance Model (TAM), which was first derived from the Theory of Reasoned Action. TAM is widely regarded as the most influential and often-used paradigm for explaining an individual's adoption of information systems and novel technologies (Davis, 1989).

Methodology

1. This study aims to investigate the prospective challenges and drivers of implementing blockchain technology in the Egyptian agrifood sector to reduce food loss. Hence, this study follows mixed methods exploratory, descriptive, and analytical to address the prospective challenges and opportunities. The study went through two phases. The first phase started with a review of pertinent literature as initial analyses to identify the opportunities and challenges of applying blockchain technology in the agrifood sector to reduce agrifood loss. The challenges derived from the literature are three main challenges and each challenge includes sub challenges. The First main challenge is the technological challenges (TC) which encompass:
2. Exposure to security problems (TC1): the term "security exposure" corresponds to a recognized weakness that can be exploited to sensitive data.
3. Scalability (TC2): Scalability within the context of blockchain pertains to the capacity of the blockchain network to effectively handle transaction processing, data storage, and reach consensus when the network experiences extra users.

Companies are hesitant to share sensitive information (TC3): The feature of transparency is a fundamental attribute of blockchain technology, enabling the creation of tamper-proof records and the efficient dissemination of information to many stakeholders. Although the concept of transparency might have advantages in some situations, it also gives rise to concerns around the management of confidential information.

1. The second main challenge is the organizational challenge (OC) which encompasses:
2. The need for huge investment (OC1): the significant allocation of resources towards the implementation of blockchain technology.
3. Eliminating intermediaries (OC2): some firms have concern about the cultural transition towards models that eliminate the need for middlemen.
4. The need for full cooperation (OC3): the need for comprehensive coordination and cooperation among supply chain stakeholders in order to attain full trust.
5. Workforce expertise (OC4): the successful implementation of emerging technologies like blockchain necessitates a workforce equipped with the necessary skills.
6. Understanding the new technology (OC5): the implementation and maintenance of blockchain technology need a considerable degree of technical proficiency due to its sophisticated nature.
7. Job losses (OC6): there exists a concern that the adoption of blockchain technology may lead to a reduction in employment opportunities.

Existing processes being disrupted (OC7): there is a concern over the potential disruption of existing procedures after the adoption of blockchain technology.

1. The third main challenge is the regulatory challenge (RC) which encompasses:

Rules governing blockchain technology (RC1): in some developing countries, governments are now in the early stages of establishing regulatory frameworks to facilitate the incorporation of blockchain technology.

In the second phase, a questionnaire was conducted to identify the most important challenges the Egyptian agrifood industry may face.

Questionnaire

The questionnaire was filled out online and employed questions derived from the literature review conducted in the first phase in order to assess the challenges, to rank them based on the perspectives of the participants. There was a Likert scale proposed for respondents to analyze their level of concern regarding the proposed challenges, where 1= very low, 2= low, 3= moderate, 4= high and 5= very high concern.

The data obtained from the questionnaire were analyzed using SPSS24, a software tool commonly employed for quantitative data analysis.

Sample Procedures

A convenient sample of 37 participants was collected from seven Egyptian agriculture organizations. The selection of the seven organizations aligns with the viewpoints of (Marcu et al., 2015), who declare that a minimum of four cases is often enough for "enhancing external validity and establishing generalizable theories". The firms were chosen based on their activities in Egypt, namely their involvement in the handling of agrifood items at a certain stage in their operations, as well as their practices of exchanging information within their existing supply chain. The participant's job titles were selected between senior executive, regional or area manager, department manager, supervisor, or operations.

The selection of participants for the questionnaire was based on their work position and professional experience within the agrifood industry, to facilitate an accurate and comprehensive analysis. 35% of the respondents were senior exectuives, 21% operation managers, 21% mentioned their work position as other, 14% department managers and 7% were supervisors.

Regarding the participant's years of experience, 50% of the participants have more than six years of experience in the field of agriculture, 7% have from five to six years experience, 29% have from three to four years of experience while only 15% have less than one year of experience.

Results and Discussion

The study variables' means, and standard deviation, are shown in Table 2. (TC1) is shown with a mean of 2.0811 and a standard deviation of 0.95389 (TC2) factor with a mean value of 3.0811 and a standard deviation of 0. 95389. Additionally, it is found the mean value (TC3) is 4.1892 with a standard deviation of 0.96718.

Additionally, the average value (OC1) is calculated to be 3.3514, with a standard deviation of 1.03323. The average value of (OC2) is 3.4054, accompanied with a standard deviation of 0.86472. The mean score for the OC3 is 3.8108, with a standard deviation of 1.07595. The (OC4) variable is determined to have a mean value of 3.2703 and a standard deviation of 1.17020. The observed variable OC5 is presented with a mean value of 3.0811 and a standard deviation of 1.58777. The observed variable OC6 has a mean value of 3.7297 and a standard deviation of 1.04479. Furthermore, it has been determined that the variable denoted as OC7 has a mean value of 3.9189, accompanied with a standard deviation of 1.08981. The observed variable (OC8) is presented with a mean value of 3.7297 and a standard deviation of 0.93240. The regulatory challenge (RC1) is found with a mean value of 4.1351 and a standard deviation of 0.88701.

It was observed that (TC1) has a less average value than the other factors. According to the result, this factor was excluded from the study and analysis.

Table 3. Descriptive Analysis of Variables

	N	Mean	Std. Deviation
TC1	37	2.0811	.95389
TC2	37	3.0811	.95389
TC3	37	4.1892	.96718
OC1	37	3.3514	1.03323
OC2	37	3.4054	.86472
OC3	37	3.8108	1.07595
OC4	37	3.2703	1.17020
OC5	37	3.0811	1.58777
OC6	37	3.7297	1.04479
OC7	37	3.9189	1.08981
OC8	37	3.7297	.93240
RC1	37	4.1351	.88701

This section presents the questionnaire responses of participants regarding the challenges that may arise during the implementation of blockchain technology in the Egyptian agrifood sector.

Technological Challenges

Table 4. Level of Concern Regarding Exposure to Security Problems (TC1)

TC1	Exposure to Security Problems				
Level of concern	Very low	Low	Moderate	High	Very high
Respondent's answers	29.73%	43.24%	16.22%	10.81%	-

According to the questionnaire results, 43% of the participants indicated that the level of concern regarding security issues such as hacking and the dissemination of inaccurate information is relatively low about the anticipated challenges that may arise following the implementation of blockchain technology in the Egyptian agrifood sector. This finding is consistent with the research conducted by Takahashi and Lakhani (2019), which suggests that the likelihood of encountering security issues decreases significantly following the implementation of blockchain technology. On the contrary, 27% of respondents have security concerns and that may be a barrier to the application of the blockchain technology in Egypt. Kumar and Mallick (2018) present a differing perspective, asserting that the adoption of blockchain technology in developing countries boosts the vulnerability to hacking. Wenhua et al. (2023) suggest that the use of encryption, authentication systems, and smart contracts plays a pivotal role in ensuring the preservation of data integrity and security throughout transactions.

Table 5. Level of Concern Regarding Scalability (TC2)

TC2	Scalability				
Level of concern	Very low	Low	Moderate	High	Very high
Respondent's answers	8.11%	10.81%	51.35%	24.32%	43.24%

Scalability in the context of blockchain refers to the capacity of a blockchain system to effectively handle an increasing number of users by efficiently processing transactions, storing data, and achieving consensus within the network. A moderate rate of scalability challenge was reported by 51% of the respondents in the questionnaire. The findings align with the research conducted by Sanka and Cheung (2021), who noted that the occurrence of scalability issues is significant. However, they also identified potential solutions to address this challenge. The implementation of expanding blocks and frequent additions of blocks to the blockchain might serve as a potential solution for mitigating scalability issues (Chauhan et al., 2018).

Table 6. Level of Concern Regarding Companies Hesitant to Share Sensitive Information (TC3)

TC3	Companies Hesitant to Share Sensitive Information				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	5.41%	5.41%	43.24%	43.24%

The unwillingness of businesses to share sensitive information poses a significant obstacle to the implementation of blockchain technology. Not all companies are currently willing to disclose their information to other participants in the supply chain, as highlighted by Badsha et al. (2020). Based on

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
http://dx.doi.org/10.21622/IBL.2023.03.1.048

the responses gathered from the questionnaire, it is evident that a significant proportion of the participants which are 86% concur that the sharing of sensitive information poses a considerable obstacle that could impede the successful adoption of blockchain technology within the agrifood sector in Egypt. One possible method to address this difficulty is to include data encryption techniques in order to guarantee restricted access to the data. Additionally, using a distributed file system across a network may provide continuous availability of all files, even in situations when network segments may fail[4].

Organizational Challenges

Table 7. Level of Concern Regarding the Need for High Investment (OC1)

OC1	The Need for High Investment				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	21.62%	24.32%	40.54%	10.81%

The potential of blockchain technology in agrifood supply chains is widely acknowledged, although its initial implementation entails significant expenses and risks. In addition to other barriers, the substantial financial investments necessary for implementing or developing the blockchain industry create barriers to entry (Dede et al., 2021). According to the study findings, nearly half of the participants in the questionnaire agreed with the notion that the implementation of blockchain technology in the agrifood sector poses a significant challenge due to the requirement for substantial investment. Elgazzar, et al. (2023) mentioned that regarding blockchain investment costs smart contracts have the potential to reduce contracting costs in the long run. Control expenses should decline but running costs remain high.

Table 8. Level of Concern Regarding the Shift in Culture toward Models that Do Not Use Intermediaries (OC2)

OC2	The Shift in Culture toward Models that Do Not Use Intermediaries				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	5.41%	51.35%	29.73%	10.81%

According to Gurtu and Johny (2019), the potential impact of blockchain technology on current operations is significant, as it offers various functions including safeguarding data integrity, facilitating immediate information sharing, and enabling programmable and automated controls. These capabilities have the potential to disrupt the existing system by reducing reliance on manual processes and intermediaries. However, a majority of 51% of the respondents agreed that this challenge may be considered moderate. Additionally, 40% of the respondents agreed that this challenge is high or very high. This perception may be attributed to the fact that Egypt is still classified as a developing country, which may result in a continued reliance on bureaucratic processes in its daily operations.

Table 9. Level of Concern Regarding the Need for Complete Coordination between Supply Chain Partners to Achieve Full Trust (OC3)

OC3	The Need for Complete Coordination between Supply Chain Partners to Achieve Full Trust				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	5.41%	35.14%	21.62%	35.14%

Hellani et al.(2021) have mentioned that the supply chain is made up of separate partners, each of which is a centralized system that works on its own. So, a lack of trust among the partners could make it hard for data to be shared openly, and more trust needs to be built. According to the respondent's answers, only 8% of the participants considered that this challenge is not significant, while 35% qualified it as moderate, and over half of the interviewees agreed it is an important challenge.

Table 10. Level of Concern Regarding Lack of Workforce Expertise (OC4)

OC4	Lack of Workforce Expertise				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	35.14%	16.22%	29.73%	16.22%

There are two workforce-related challenges: employees who do not comprehend the technology or who lack cross-industry work experience (Yadlapalli et al., 2022). According to the questionnaire results, almost 37% of the participants agreed with the idea that the lack of workforce expertise is a difficulty of relatively low relevance, while 16% categorized it as moderate. However, almost 55% of the respondents acknowledged it as a significant challenge. This

4 How Blockchain Can be Used to Secure Sensitive Data Storage - DATAVERSITY

perspective may be attributed to the proactive approach of managers who are keen on adopting blockchain technology for organizational benefits. These managers demonstrate initiative by actively providing the necessary training to cultivate a skilled workforce proficient in blockchain technology. Consequently, they do not perceive this challenge as a significant obstacle.

Table 11. Level of Concern Regarding Lack of Understanding of the New Technology (OC5)

OC5	Lack of Understanding of the New Technology				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	24.32%	16.22%	16.22%	13.51%	29.73%

A significant obstacle identified by 29% of the participants in the survey was the lack of awareness of the new technology. This lack of understanding stems from a lack of clarity regarding the integration of blockchain technology into their current business models and systems. Furthermore, it is important to remember that Egypt, being classified as a developing nation, has yet to fully recognize the importance of integrating digital processes into its business operations. Consequently, there remains a significant number of companies within the country that continue to favor traditional paper-based systems. This viewpoint aligns with the findings of Chang et al. (2019), who noted that a significant obstacle faced by the workforce in underdeveloped nations is their limited comprehension of the emerging blockchain technology.

Table 12. Level of Concern Regarding Fear that Implementing Blockchain May Result in Job Losses (OC6)

OC6	Fear that Implementing Blockchain May Result in Job Losses				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	16.22%	5.41%	56.76%	18.92%

Move table 12 from above and add it in this space
Based on data provided by the Central Agency for Public Mobilization and Statistics (CAPMAS), the unemployment rate in Egypt was at 7.1% during the first quarter of 2023[5]. There are two primary factors contributing to job loss after adopting blockchain technology: automation of certain tasks and employees' inability to swiftly adapt and fulfill the new requirements associated with blockchain technology (Kodym et al., 2020). A significant proportion of the participants in the questionnaire, comprising 75%, have assigned a high to very high rating to this particular challenge. However, Chang et al. (2019) mentioned that fear of job losses after adopting blockchain technology have proven to be unsubstantiated, since there is a lack of evidence indicating any reduction in employment due to blockchain technology.

Table 13. Level of Concern Regarding Worry about the Existing Process Being Disrupted (OC7)

OC7	Worry about the Existing Process Being Disrupted				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	10.81%	13.51%	37.84%	35.14%

Some of the decision-makers are discouraged from embracing the new technology because of the possibility that implementing blockchain technology may result in the disruption of their existing business model (Nowiski & Kozma, 2017). As per the data collected from the questionnaire, it was found that 13% of the participants expressed their opinion that this challenge lacks significance, while the majority of the interviewers agreed that it represents a serious difficulty.

Table 14. Level of Concern Regarding Many Businesses Are Still Confused about Blockchain Capabilities of Advantage (OC8)

OC8	Many Businesses are Still Confused about Blockchain Capabilities of Advantage				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	10.81%	10.81%	62.16%	13.51%

Several businesses, especially those in developing countries, are still unsure of the benefits and potential of adopting blockchain technology (Morkunas et al., 2019). Given that Egypt is now categorized as a developing nation, it follows that blockchain technology is relatively novel to its users. Consequently, 75% of respondents in the questionnaire have attributed a noteworthy level of importance to this specific challenge.

5 Central Agency for Public Mobilization and Statistics (CAPMAS)

Volume 3, Issue 2, December 2023 - ISSN 2735-5969
http://dx.doi.org/10.21622/IBL.2023.03.1.048

Regulatory Challenges

Table 15. Level of Concern Regarding That There Are No Rules Governing Blockchain Technology in Egypt (RC1)

RC1	There Are no Rules Governing Blockchain Technology				
Level of concern	Very low rate	Low rate	Moderate	High rate	Very high rate
Respondent's answers	2.70%	-	16.22%	43.24%	37.84%

Belarus has the distinction of being the first country to establish a formal regulatory framework for the blockchain operations. However, due to the fact that blockchain is still a developing technology, it will take some time before it is fully implemented. In several countries like India, Russia, South Korea and Thailand, the government is now in the nascent phase of formulating regulatory frameworks for the integration of blockchain technology. Hence, many businesses and organizations hesitate to implement blockchain technology because regulations are still in the process of being developed. As there are no regulations and laws governing the adoption of blockchain, it is difficult for every organization to do so, especially in developing countries (Akram et al., 2020). Considering Egypt is still a developing nation, 81% of questionnaire respondents regarded this challenge as highly significant.

Conclusion and Recommendations

Blockchain technology is an advanced innovation with significant potential to enhance the reduction of agrifood loss, traceability, and agrifood quality by offering robust security measures and complete transparency. Nevertheless, the comprehensive examination of the advantages, difficulties, and approaches to the advancement of food traceability systems based on blockchain technology remains incomplete in the existing scholarly works. Hence, the primary objective of this study is to ascertain the key obstacles and determinants impacting the acceptance of blockchain technology within the agrifood sector. This will be accomplished by examining relevant scholarly works and assessing the relative importance of potential barriers that may emerge during the integration of blockchain technology in the Egyptian agrifood industry.

The findings of this research contribute to a deeper comprehension and enhanced knowledge about the utilization of blockchain technology in the Egyptian agrifood business. This study sheds light on how such implementation might lead to improvements in reducing agrifood loss and enhancing agrifood quality. Nevertheless, decision makers in Egypt will encounter many obstacles when using blockchain technology.

The literature highlights many key hurdles associated with the adoption of blockchain technology, including technical challenges, organizational challenges, and regulatory challenges. Technical challenges include issues such as security vulnerabilities scalability limitations and unwilling to exchange sensitive information. Organizational challenges involve the need for huge, eliminating intermediaries, the need for full cooperation, workforce expertise, understanding the new technology, job losses and fear of existing processes being disrupted. While regulatory concerns pertain to compliance with existing regulations and potential legal implications.

Moreover, based on the findings from the questionnaire, it was discovered that the primary problems with the highest percentages of concern were that companies are reluctant to provide sensitive information, the absence of Egyptian rules controlling the implementation of blockchain technology, fear of job losses, fear over the potential disruption of current procedures and there exists a degree of uncertainty among some firms about the full potential and capabilities of blockchain technology, while the prospect opportunities associated with lowering agrifood loss include enhancing agrifood supply chain traceability, fostering collaboration, and improving efficiency.

Theoretical Contribution

The use of blockchain technology in the food sector is experiencing growth, presenting a promising potential for both theoretical and practical advancements in the realm of blockchain-enabled food supply chains. Accordingly, this study is making theoretical contributions to the literature review of the field of blockchain technology. The theoretical foundation of this study is rooted in the Technology Acceptance Model (TAM) developed by Davis (1989). The adoption of blockchain technology is contingent upon several aspects, including the perceived ease of use, preparation of the company, degree of understanding, perceived benefit, and attitude towards actual system use. Many obstacles hinder the initial implementation of new technologies from the standpoint of different organizations. Nevertheless, when these technologies are well-strategized and designed with a sound framework and architecture, they may overcome significant hurdles to their acceptance (Tan et al., 2021).

This study addresses a research gap by examining the primary challenges associated with the adoption of blockchain technology in Egyptian agricultural organizations. While previous studies, such as Gruchmann et al., (2023), Farouk and Darwish (2020), and El-Zonkoly (2021) have contributed to the literature review on blockchain adoption in Egypt by exploring various perspectives and elements in different sectors like energy, pharmaceutical, and banking. However, this study takes a different approach by investigating the level of concerns related to the challenges that may arise after implementing blockchain technology in the Egyptian agrifood sector, with the goal of mitigating agrifood losses. From the researcher's perspective, this study provided future researchers and academics with new issues for future research and potential collaborations in the field of adopting blockchain technology in the Egyptian agriculture sector which designed the mind stones for the researcher and this will support future research too. Moreover, this research elucidates the primary obstacles that may arise as a consequence of implementing a new technology such as blockchain, especially in developing countries. These challenges are regarded as a vital aspect in initiating future research endeavors. Besides, this study answers the call of Vern et al. (2023) which stated that developing countries need more investigation related to the adoption of blockchain technology.

Practical Contribution

The outcomes of this research have the potential to offer valuable insights for agrifood managers, blockchain technology service providers, and governmental entities. These insights can be utilized to formulate effective strategies and regulations that facilitate the successful implementation of blockchain technologies in the Egyptian agrifood sector with the ultimate objective of mitigating agrifood loss.

Recommendations

This section will outline certain issues that arise from the use of blockchain technology in the Egyptian agrifood industry. Additionally, it will provide a set of suggestions that managers may utilize to address these challenges effectively. These suggestions have been derived from prior research studies that have addressed strategies for addressing issues in the field of blockchain technology.

Table 16. Blockchain Adoption Challenges and Their Suggested Solutions

Blockchain Adoption Challenges	Suggested Solutions
Security issues	The use of encryption, authentication mechanisms, and smart contracts is crucial in safeguarding the integrity and security of data and transactions.
Scalability	Expanding blocks and frequent blockchain block additions.
Need for high investment	Smart contracts lower contracting expenses over time. Control expenses should decline but running costs remain high.
Lack of trust among users	A permission-based blockchain network may provide immutability, privacy, and traceability for shipping documents where there are no unknown users.
Lack of skills	It is recommended that companies commence the recruitment and training of new-collar employees.
Lack of regulations	To further facilitate the agrifood industry's use of blockchain technology, the Egyptian government should initiate the establishment of rules to control blockchain operations.

Appendix (1)

The hyperlink to the online questionnaire. https://forms.gle/DTeGSaVLc25V

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