Uncertain Supply Chain Management 9 (2021) 1071–1080

Contents lists available at GrowingScience

Uncertain Supply Chain Management

homepage: www.GrowingScience.com/uscm

The benefits and challenges of RFID technology implementation in supply chain: A case study from the Turkish construction sector

Samer Hamadneh[a], Elif Keskin[b], Muhammad Alshurideh[a*], Yazeed Al-Masri[a] and Barween Al Kurdi[c]

[a]*Department of Marketing, School of Business, The University of Jordan, Amman 11942, Jordan*
[b]*Stock and Demand Planning Specialist, Turkey*
[c]*Department of Marketing, Faculty of Economics and Administrative Sciences, The Hashemite University, Zarqa, Jordan*

C H R O N I C L E

Article history:
Received June 18, 2021
Received in revised format October 8, 2021
Accepted December 28 2021
Available online December 28 2021

Keywords:
Warehouse Management
RFID
Benefits
Challenges
Construction sector

A B S T R A C T

Radio Frequency Identification Device (RFID) has been widely recognized as a useful tool for effectively managing firms' supply chain activities. Extant research on RFID in the supply chain domain has focused on implementing this technology in various supply chain activities, such as logistics and transportation, assembly and manufacturing. However, the application of RFID in warehousing management has received little attention. This study explores the implementation of RFID in warehousing in the construction sector. The study objectives are twofold. First, it explores the benefits of implementing RFID. Secondly, the study identifies major challenges associated with implementing RFID, which can prevent realizing the full potential of the technology in warehouse operations. The study adopts a qualitative research design by employing a case study approach to achieve these objectives. Specifically, the study undertakes three weeks of field observation and conducts interviews with 9 participants involved in warehouse operations in the construction sector. The findings show RFID implementations could bring significant values to warehouse management related to operational efficiency, service level and warehouse flexibility. However, the study also uncovered several challenges that can block the case firm from capturing the full potential of implementing RFID. The findings can contribute to a better understanding of the application of RFID technology in warehousing. Practitioners can understand the identified challenges to help them tackle them and inform their future decisions regarding further investment in this technology.

1. Introduction

Radio Frequency Identification Device (RFID) is an automated data collection and identification technology. RFID is made up of three components: a tag generated by a chip connection with an antenna; a reader that emits radio signal and in response receives tag information; and the middleware that interfaces the RFID hardware and designated software application that stores the information exchange (Want, 2006; Sarac et al., 2010; Finkenzeller, 2010). The benefit of RFID lies in its ability to use radio waves to identify, record, track objects (Finkenzeller, 2010; Angeles, 2005). In addition to tracking, RFID supports several business activities, including e-commerce activities and many other core activities, such as inventory management, Vendor Managed Inventory (VMI), and supply chain coordination (Smaros & Holmstrom, 2000; Jarugumilli & Grasman, 2006; Lee et al., 2022a&b). Hence, RFID technology can see more advanced improvement over conventional barcode systems, which are paper-based and easily spoiled or damaged. Therefore, it is unsurprising that many large firms such as Walmart, Tesco, Michelin, and Target have employed this technology today in their various business activities (Kgobe & Ozor, 2021).

* Corresponding author
E-mail address: m.alshurideh@ju.edu.jo (M. Alshurideh)

doi: 10.5267/j.uscm.2021.x.006

It has been well documented that Supply chain and logistics management is among the largest beneficiaries of RFID technology (Kgobe & Ozor, 2021; Li, Godon, & Visich, 2010). RFID studies within supply chains have typically revolved around areas such as logistics and transportation, assembly and manufacturing, asset identification and tracking, location monitoring and environmental conditions, among others (Gaukler and Seifert, 2007; Garrido Azevedo and Carvalho, 2012). However, there has been less research on the adoption of RFID technology in warehousing operations (Lim, Bahr, & Leung, 2013). As stated by Kgobe & Ozor (2021, p.297) "In particular, application of RFID in management of warehousing systems has not received serious attention". This is surprising because the current theory posits that warehouse management plays a vital role in the success or failure of any supply chain (Kiefer and Novack, 1999; Faber, de Koster, & Smidts, 2013). While there is a consensus in the warehouse management literature that managing complex warehouses effectively and efficiently has become a challenging task (Biswal, Jenamani, & Kumar, 2018; Faber et al., 2013), extant research suggests that Radio Frequency Identification (RFID) technology can be a useful tool to address warehousing problems such as inventory inaccuracy (Biswal et al., 2018), because it enables real-time communication with numerous objects simultaneously from a distance without line of sight (García et al., 2007; Shamout et al., 2022; Delen, Hardgrave & Sharda, 2007). Hence, the primary aim of this study is to explore the application of RFID in warehousing operations in the construction goods sector (CGS). We chose the construction sector in Turkey for two main reasons. First, according to Gul and Cakaloglu (2017), While the construction sector is one of the leading sectors in Turkey's economy, it has not employed technology at a significant level. Hence, as this sector is expected to grow further, it can be argued that supply chain members of this sector may experience more delays in accessing required materials at the right time. Second, the body of current and previous research shows that little research has been conducted outside of the developed markets. Therefore, conducting this study in a developing economy, such as Turkey, will further extend the scope of current studies and it also may uncover interesting insights of phenomena investigated.

Based on the above research background, the study attempts to answer the following two research questions:

RQ1: What are the benefits of RFID adoption in warehouse operations in the construction sector?
RQ2: What are the challenges associated with applying RFID technology?

The paper is organized as follows. Section 2 provides the theoretical foundation, which informs the study and summarises the relevant literature. Section 3 outlines the research design utilized in this study to answer the research questions. The fourth section presents key findings and discusses these findings in relation to previous research. Section 5 summarises key findings, highlights main contributions and outlines some limitations of this study.

2. Literature Review

2.1 Warehouse management and its importance in the supply chain

Mentzer et al., (2001, p.4) defined a supply chain as a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer. Supply Chain Management (SCM) on the other hand, refers to the synchronization and coordination of these activities to reach a common goal which benefits both the individual supply chain actors and the supply chain as a whole (Mentzer et al., 2001; Christopher, 2011; Alshurideh et al., 2022). It has been well established that the efficiency and effectiveness of a supply chain network depend largely on the performance of various actvities, in particular warehouse management (Alzoubi et al., 2020; Rouwenhorst et al., 2000; Alshurideh, 2022). Warehouse management has been defined as "*a combination of the planning and control systems and the decision rules used for inbound, storage, and outbound flows*" (Faber et al., 2013, p.1232). Typical planning issues in warehouses revolve around inventory management and storage location operations. For example, receiving materials, putting them away, storage, order picking and despatching items are core warehouse operations (Gu et al., 2007).

The literature has emphasized the importance of warehouse management for effective and efficient supply chains. Effective warehouse management better enables managers to respond to changing market conditions and deal with production and demand fluctuations (Lim et al., 2013; Alshurideh et al., 2019). Furthermore, warehouses may also perform a range of value-added processes, such as labelling, assembling, break-bulk, unpacking, and repacking. Moreover, warehouses create important links between suppliers and customers by overcoming space and time distance between them, ensuring the maintenance of the desired customer service levels, consolidating multiple orders into one delivery and supporting just-in-time agreements between suppliers and customers (Lim et al., 2013; Joghee et al., 2021; Hamadneh et al., 2021). Therefore, companies seek many developments in warehouse operations to enhance their supply chains performance (Koster et al., 2007; Ramaa et al., 2012; Faber et al., 2018). With this in mind, automated systems have been predominantly perceived as a promising tool to increase operational efficiency and meet the expectations of both customers and the company itself (Alzoubi et al., 2022; Hasan et al., 2022; Tariq et al., 2022a&b). In particular, RFID technology has received significant attention from logistics and supply chain industry practitioners and academics alike. Hence, the section that follows reviews the RFID technology in the supply chain context.

2.2 RFID in the context of Supply Chain Management

Radio Frequency Identification (RFID) is an automated data collection and identification technology. RFID is made up of three components: a tag generated by a chip connection with an antenna; a reader that emits radio signal and in response receives tag information; and the middleware that interfaces the RFID hardware and designated software application that stores the information exchange (Want, 2006; Sarac et al., 2010; Finkenzeller, 2010). It uses radio waves to identify, record, track objects (Finkenzeller, 2010; Angeles, 2005; Auto-ID centre, 2019). Several RFID studies within the domain of supply chains have been conducted. These studies investigated the application of this technology in areas such as logistics and transportation assembly and manufacturing, location monitoring and environmental conditions and inventory management (Gaukler & Seifert, 2007; Garrido Azevedo & Carvalho, 2012). Various industries have benefited from adopting RFID technology, including the automotive industry (Hedgepeth, 2006; Wang et al., 2010) and healthcare (Banks et al., 2007; Yao et al., 2010; Wamba et al., 2013).

It has been reported that RFID technology can address various problems in the supply chain. For instance, RFID can reduce inventory inaccuracy which can happen due to theft and misplacements, bullwhip effect due to information delay and ineffective replenishment policy due to imperfect information (Sarac et al., 2010). RFID technology also enables more visibility of the items in warehouses as it captures the data about production and expiration date, characteristics of products and their moves (Chen et al., 2013; Castro and Wamba, 2007). The benefits of RFID are well-perceived by industry, including retail, logistics, manufacturing, the military, healthcare, pharmaceuticals and the service sector (Oztaysi et al., 2009; Ngai et al., 2008). These benefits include unique identification of each tagged item and status monitoring, improved stock visibility and traceability at any stage in the supply chain, increased data accuracy and sharing, automated inventory counts, automated receiving and scanning, reduced shrinkages, and so on (Baker, 2005; Brown et al., 2007; Ngai et al., 2008; Ghazal et al., 2021; Nuseir et al., 2021; Svoboda et al., 2021). However, despite the great potential for this technology to the supply chain activities, previous research has shown many challenges associated with adopting and implementing. For example, White et al (2007) pointed out that companies may not necessarily achieve the full potential due to many challenges such as adoption problems, IT related hindrances, uncertainty of ROI from deploying this technology. Lim's and colleagues found out that lack of knowledge of RFID was the main reason why firms may not consider deploying this technology. Similarly, Chong & Chan (2012) argued that top management of firms are less likely to adopt the technology, especially if the value has not been demonstrated compared to the high costs.

Extending previous empirical studies in RFID, this study focuses on exploring the value and challenges involved in adopting RFID technology in the context of warehouse management. This area has received little attention in previous studies (Kgobe & Ozor, 2021). Indeed, extant research suggests that Radio Frequency Identification (RFID) technology can be a useful tool to address warehousing problems such as inventory inaccuracy (Biswal et al., 2018). This technology can achieve this as it enables real-time communication with numerous objects simultaneously from a distance without line of sight (García et al., 2007). Hence, this study responds to previous calls for more understanding of the implementation of RFID technology in diffident supply chain contexts and in different countries (Kgobe & Ozor, 2021; Li et al., 2010; Lim et al., 2013).

3. Research Methodology

From our research, we identified that little research has been devoted to exploring the application of RFID technology in warehouse operations. Consequently, to develop more understanding of the value and challenges associated with employing RFID technology warehouse operations in the Turkish construction sector, a case study approach has been adopted to answer the two research questions. The case study approach enables investigation of multifaceted issues within their contexts (Yin, 1994) and provides an understanding of the dynamics of the phenomena in question (Eisenhardt, 1989).

We restricted our selection to a single case with a global company with construction operations in Turkey but managed by a foreign parent company. The company produces and stocks a wide range of products, including customized and imported products, and has a varied shelf life from 6 months to 2 years. Although the case firm adopts "*Just in Time"* approach of production, mass production is adopted for operational efficiency by manufacturing items according to demand from the customers to keep stock level minimum in the warehouse. However, this can cause various problems, such as not accommodating all products to available shelves due to variations in sales volumes. Our case firm has partially adopted RFID for ten years in one of its warehouses to manage products, particularly for liquid products. Hence, choosing the case study approach can be useful to uncover the benefits and the challenges associated in applying the RFID technology so far and how this might affect the firm's decision to expand employing this technology on a larger scale in the future.

Data were collected from two main sources: semi-structured interviews and direct observation. First, three weeks of observations were made throughout the warehouse facilities to experience implementing RFID technology in practice. This direct observation enabled direct interaction with warehouse staff and managers, facilitating information exchange informal meetings (Dubois & Gadde, 2002; Yin, 2009). This was followed by conducting semi-structured interviews with 9 participants with different roles and responsibilities related to using and applying RFID technology in warehouse facilities. The

participants' profile is presented in Table 1. Semi-structured interviews were selected as being most likely to yield new insights during the conversation between the interviewee and the participants (Myers & Newman, 2007).

Table 1
Participants' profile

Participant	Position in the firm	Years of experience
P1	Logistics and warehouse management manager	2
P2	Logistics and warehouse management specialist	5
P3	Customer support manager	23
P4	User	3
P5	Senior logistics officer	14
P6	Information technology manager	6
P7	Quality control manager	13
P8	User	4
P9	User	5

In addition, participants were encouraged to express their views freely and raise new issues relevant to the studied phenomenon (Ryan, Tähtinen, Vanharanta & Mainela 2012). The interview questions were informed by the ideas reported in the previous literature. However, based on the nature of the conversation, the order of the questions was not consistent from one interview to another, and not all questions were asked explicitly. The interview guide is presented in Appendix 1. Each interview lasted between 30 minutes and 60 minutes on average, and all interviews were recorded and transcribed. All interviews were conducted face-to-face.

4. Findings and Discussion

The primary aim of this study was to develop a better understanding of the benefits and challenges associated with applying RFID technology in warehouse operations in the construction sector in Turkey. Specifically, the research questions were: (1) What are the benefits of adoption of RFID in warehouse operations in the construction sector? (2) What are the challenges associated with applying RFID technology? A single case study with a Turkish construction firm was employed to answer these questions, and semi-structured interviews were utilized for data collection. Interview transcription was analyzed using template analysis as presented by King (2018). The template was developed around two main themes: the benefits of RFID implementation and the challenges of RFID implementation. These themes are presented and discussed in the next subsections.

4.1 Benefits of RFID implementation in warehouse operations

The first research question was formulated to identify the main benefits of applying RFID technology in warehouse operations in the Turkish construction sector. Results of interviews indicate that the benefits of RFID technology can be classified into three major themes, operational efficiency, service level and warehouse flexibility, respectively. These benefits will be explained below.

4.1.1 Operational efficiency in the warehouse

The first benefit that can be realized from applying RFID in warehouse management is improving operational efficiency. Operational efficiency in the warehouse relates to completing daily operations with minimum cost, time and labour (Lim et al., 2013). Three sub themes emerged during the analysis, elucidating how RFID can improve operational efficiency. First, operational efficiency can be achieved by making the job easier for staff warehouses and managers alike. In particular, RFID helps users pick orders from the right shelves within optimal time. P9 highlighted that picking operations is one of the most strenuous and complex tasks in a warehouse, especially for companies with huge warehouses such as theirs. Hence, RFID systems can allow users to decrease effort and time during picking operations. As stated by P1:

"[…] users can read the product and assign products to the shelves easily. After we started using the system [RFID], finding the location assigned to each item became easier. […]" [P1]

This has been enabled as the reader enables a bridge between system and operation to enter assigned shelves for products. Thus, the next user could easily see the location of products without much effort for searching. For managers, RFID enables monitoring operators and operations remotely as managers are more informed of warehouse staff and their assigned jobs. As one interviewee said:

"It is a remarkable technology. Previously, you had to be on the spot and standing over their heads, whereas now you are the one holding the steering as manager." [P3]

Secondly, time reduction was another benefit of using RFID, ultimately improving operational efficiency. Time issues have become vitally important, particularly when fulfilling customers' orders within the supply chain (Angeles, 2005; Kgobe & Ozor, 2021). Informants reported that automated systems such as RFID could significantly reduce the time needed to fulfil orders. One participant commented:

"It is all about time, as we race against time, it is [RFID] hugely time-saving" [P3]

Specifically, RFID helps save time in warehouse operations by directing operators to the exact location of items rather than spending that time searching in large warehouses (Faber et al., 2013). However, one interesting finding is that some participants reported that using RFID can sometimes increase the time needed to perform operations if not employed properly and thus making warehouse staff even work harder and longer. This view was shared by P4, who stated:

"[…] but there might also be a disadvantage when you use the reader, we should not be reading the product wrongly. In which case, it becomes meaningless to search for a product in the whole warehouse. […] It is huge time consuming for us." [P4]

Thirdly, participants also noted that operational efficiency can be achieved as RFID technology allows warehouse managers to analyze and capture all data regarding items' movements and waiting times. Indeed, RFID technology can keep records about location, waiting time in the warehouse or its frequency of movements to analyze data later for business development projects in the warehouse (Biswal et al., 2018; Faber et al., 2013). P2 also added that capturing data might help them find out and eliminate unnecessary movements and waiting times to increase operational efficiency in the warehouse. The three-week observation period gave another example of how RFID enables data analysis. It was noted that warehouse workers relied on this technology to apply FIFO (first in, first out) method by ensuring that the oldest stock of inventory is shipped out first. Thus, RFID brings the applicability of automated FIFO in warehouses and decreases users' workload in terms of unnecessary movement and time spent checking products' production dates.

4.1.2. Service Level improvements

The second main benefit derived from implementing RFID in warehouse operations is related to the service level improvements. By service level, we mean by the extent to which applying RFID helps in improving the overall customer service while improving the current warehouse operations. P7 explicitly addresses this point:

" […] it is [RFID] important to keep the right balance between customer satisfaction and our operation goals." [P7]

Service level can be improved using RFID because this technology facilitates information exchanges and collaboration with customers, thus fulfilling their orders, leading to higher customer satisfaction (Kgobe & Ozor, 2021; Li et al., 2010). Thus, the service level is considered as a combination of all customer satisfaction, quality of products and speed of deliveries. In other words, a decrease in the inaccuracy of shipments, reducing the risk of sending outdated products, and quick access to products' information are the most desired benefits of RFID by employers. P1 described how implementing RFID help in meeting service level:
"[…] think about you having a problem just in the middle of the construction process. So when the customer calls us, we should provide a quick solution. For this purpose, we need to find where the item, production time, and batch number are." [P1]

4.1.3. Warehouse Flexibility

The third benefit realized when implementing RFID technology in warehouse operations is warehouse flexibility. By this, we mean that RFID allows placing items to allow maximum utilization of warehouse capacity. In his view, P5 explained that RFID enables them to locate products to the most suitable shelves in the warehouse. Further, he also stressed that when the same product exists as both pallet and single item in the warehouse, operators are no longer limited for replacement within the same area. So, RFID enables us to assign products to the most suitable places to ease picking for the next operator. As a result, the warehouse could be used with nearly full capacity and efficiency. This result is in line with those of previous studies which found that RFID technology can resolve inefficiencies in the warehouse such as poor storage space utilization, misplaced stocks, and errors in inventory records (Lim et al., 2013; Mabad, Ali, Ally, Wamba, & Chan, 2021)

On the other hand, a recurring theme emerged from the data that the company has not used the RFID technology in all warehouse operations, thus raising concerns that more benefits can be achieved from implementing RFID technology. Hence, we were keen to learn why RFID couldn't be applied to other operations and understand the company's challenges from gaining more value. Challenges associated with implementing RFID are presented next.

4.2 Challenges of implementing RFID

The second research question in this study was formulated to identify the main challenges associated with applying RFID technology in warehouse operations in the Turkish construction sector. Results of interviews showed that challenges of RFID technology could be classified into four major themes, lack of adoption, managerial issues hinder, system and warehouse related hinders and lack of financial resources, respectively.

4.3.1. Lack of technology acceptance

The findings suggest that there seems to be a Lack of acceptance of new technologies such as RFID from both users and warehouse managers. As a result, this was found to hinder the widespread adoption of RFID in warehousing. First, it was observed that some warehouse workers were reluctant to use data generated by the system, preferring doing the work in the old fashion. Interview participants identified a couple of reasons why lack of acceptance can prevail in warehousing, such as lack of understanding, getting used to traditional ways of doing things and concerns over workforce privacy. The comment below illustrates this notion further.

"It was difficult to adopt it at an early implementation stage for users and even for us as managers because it is difficult to change habits. [P3]

Therefore, P5 put forward the need to constantly educate users and warehouse operators to increase the adoption level;
"RFID users should be educated about the system, so all users know its value. By this only, we can ensure our guys are implementing this." [P5]
So, P3 also suggested solutions as giving users both full information and the opportunity to explore the system. However, another mentioned reason for the slow adoption of RFID is concerns about the privacy of the workforce since the technology allows trace people and objects everywhere and all the time. Hardgrave and Miller (2006) argued that this can create resistance and opposition to the technology.

4.3.2. Managerial issues Hinders

Given that our case firm is managed and controlled by a parent company, the study has demonstrated further obstacles to the ones previously mentioned in the literature (e.g., Lim et al., 2013), which impede capturing the full value of the technology. For example, our data suggest that the parent company may take a considerable amount of time in approving various issues such as system maintenance and update. This was found to serve as a hindrance to realizing the full potential of RFID. This point was explained by P6, who explained that their IT department needs to wait until the parent company approves updating and upgrading the system. In addition to that, P3 also highlighted that lack of proper cooperation between various units such as the logistics unit and IT can impede utilizing the full potential of RFID technology.

4.3.3. system and warehouse related Hinders

Data also reveal that the lack of integration of RFID with other systems used in the warehouse and other functions in the firm can also impede the full optimization of RFID technology. This can confuse the warehouse workers and require them to access different systems to make sense of information (Rim & Park, 2008). One informant reported that:

"*There are multiple platforms and systems that we need to work through, and the system [RFID] is not compatible with these platforms*". P8

Meanwhile, a few informants expressed concerns about the system's functionality when operated in the construction sector. For instance, P3 further explained that the dusty texture of some construction products might block GPS signals because of the environment in the warehouse. In addition, P6 agreed network connection problems for some locations in the warehouse might be a challenge that can cause difficulty in receiving GPS signals at locations in the warehouse area. Further, he also added that when a connection problem occurs during the implementation process, this can cause the system to go down.

Talking about challenges due to system components, some informants highlighted battery problems and readers' ergonomics and added the need for a more user-friendly interface.

4.3.4. Lack of Financial resources

Senior managers noted that it is always hard to predict the profitability of the construction goods sector due to its huge size. This was found to affect management commitment and willingness to invest in upgrading and expanding RFID technology. All participants noted that many items in the warehouse are low-cost goods with little profitability, which can discourage management from expanding RFID into other warehouse operations. P6 mentioned budget as the first obstacle for IT improvements due to the cost of devices, which is difficult to recoup its expense in the short term, limiting management's

willingness to invest in improving the current system. This result is consistent with those of Li et al., (2010), who found that financial issues can be a barrier to lack of adoption of RFID technology. P6 argued that analyzing the value of RFID within the short term might be difficult for the construction goods sector and stated that top management should focus on the long-term benefits obtained from adopting the system. Fig. 1 summarizes the benefits and challenges of adopting RFID technology in the construction sector based on the empirical data and the observation period. The figure illustrates the connection between major values and challenges of RFID investigated in this case in the construction goods sector. What stands out in this figure is that the time factor can be very dynamic and can change the workforce's perception of RFID technology. The faster the firm can overcome the challenges highlighted above; the more attention would be directed at the values of this technology and thus increasing the adoption level. This can lead to increased operational efficiency, service level and warehouse flexibility. In contrast, further delays in addressing these challenges will make it more difficult to create a positive mindset towards accepting the system among the workforce, which may affect the overall service level and reduce operational efficiency.

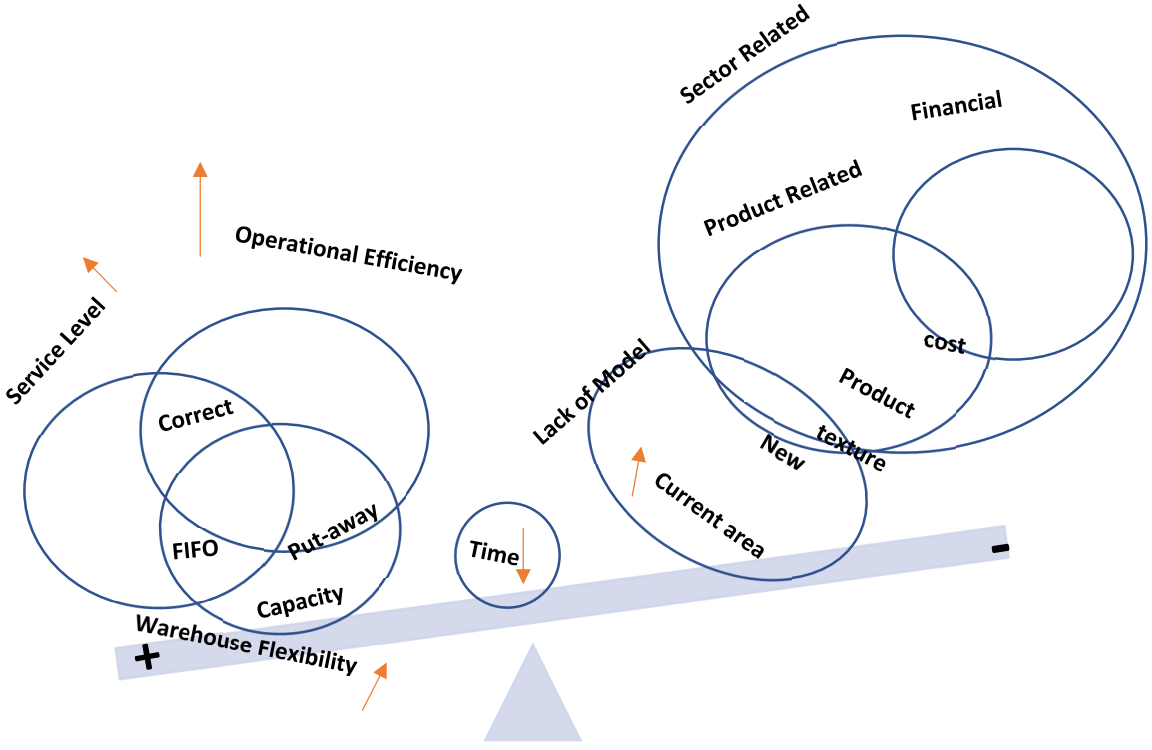

Fig. 1. Identified benefits and challenges of adopting RFID technology in the Construction sector based on the study findings.

5. Implications and Limitations

This paper responds to calls (e.g., Kgobe & Ozor, 2021; Lim et al., 2013) for providing further insights on RFID implementation in warehousing. Hence, this study aimed to better understand the benefits and challenges of adopting RFID technology warehouse operations in the construction goods sector. The study contributes to RFID literature within the domain of the supply chain. It provided empirical insight into RFID implementation in warehouse operations. Findings suggest various benefits from adopting RFID technology in warehouse operations, including increasing operational efficiencies, service level improvements and warehouse flexibility. Most importantly, the findings of this research highlighted some unique issues in respect to RFID implementation in warehousing in the construction goods sector. For instance, issues such as low sector profitability can largely affect the management's decision to adopt RFID technology at a large scale. Further, it was interesting to learn that the nature of some product characteristics (e.g., texture and dusty products) in the warehouse in the construction sector can affect the quality of the system. Hence, this is one of few qualitative studies using observation and case study as a research design to investigate RFID in warehouse operations in the construction sector. Practitioners in the construction goods sector need first to understand the benefits of adopting RFID technology in the long term to justify the need to invest in this technology. Hence, in the low profitability sector, RFID solutions providers have to be proactive, and approach firms operating in the construction sector and demonstrate its value in the long term.

Like any other study, this study has some limitations. First, the number of interviews conducted is relatively low. Secondly, the findings of this study must also be generalized with caution. As this study adopted one single case firm from Turkey, it is

not easy to generalize the findings to other sectors in different countries. Similarly, different warehouse operations in the world may have different barriers (e.g. connection issues, lack of system integration etc.) to fully realize the benefits of RFID implementation. This suggests that this study's findings may not apply to all warehouse operations in the construction sector. Future research should focus on obtaining data from larger samples to generalize its findings better. Also, conducting a study over a longer time frame could measure the actual trade-off of costs and benefits of implementing RFID in low profitability sectors.

References

Alshurideh, M. (2022). Does electronic customer relationship management (E-CRM) affect service quality at private hospitals in Jordan?. *Uncertain Supply Chain Management*, 10(2), 325-332.

Alshurideh, M. T., Al Kurdi, B., Alzoubi, H. M., Ghazal, T. M., Said, R. A., AlHamad, A. Q., ... & Al-kassem, A. H. (2022). Fuzzy assisted human resource management for supply chain management issues. *Annals of Operations Research*, 1-19.

Alshurideh, M., Alsharari, N. M., & Al Kurdi, B. (2019). Supply chain integration and customer relationship management in the airline logistics. *Theoretical Economics Letters*, 9(02), 392-414.

Alshurideh, M., Gasaymeh, A., Ahmed, G., Alzoubi, H., & Kurd, B. (2020). Loyalty program effectiveness: Theoretical reviews and practical proofs. *Uncertain Supply Chain Management,* 8(3), 599-612.

Angeles, R. (2005). RFID technologies: supply-chain applications and implementation issues. *Information systems management*, *22*(1), 51-65.

Alzoubi, H. M., & Alshurideh, M., Al Kurdi, B., Inairat, M. (2020). Do perceived service value, quality, price fairness and service recovery shape customer satisfaction and delight? A practical study in the service telecommunication context. *Uncertain Supply Chain Management*, *8*(3), 579-588.

Alzoubi, H., Alshurideh, M., Kurdi, B., Akour, I., & Aziz, R. (2022). Does BLE technology contribute towards improving marketing strategies, customers' satisfaction and loyalty? The role of open innovation. *International Journal of Data and Network Science*, 6(2), 449-460.

Baker, P. (2005). Will tags get out into the supply chain? *Works Management 58*(2), 34–37.

Berg, J. P. V. Den, & Zijm, W. H. M. (1999). Models for warehouse management: Classification and examples. *International Journal of Production Economics*, *59*(1), 519–528. https://doi.org/10.1016/S0925-5273(98)00114-5

Biswal, A. K., Jenamani, M., & Kumar, S. K. (2018). Warehouse efficiency improvement using RFID in a humanitarian supply chain: Implications for Indian food security system. *Transportation Research Part E: Logistics and Transportation Review*, *109*(November 2017), 205–224. https://doi.org/10.1016/j.tre.2017.11.010

Brown, I., & Russell, J. (2007). Radio frequency identification technology: An exploratory study on adoption in the South African retail sector. *International journal of information management, 27*(4), 250-265.

Castro, L., & Wamba, S.F. (2007). An inside look at RFID technology. *Journal of Technology Management & Innovation*, *2*(1), 128-141.

Christopher, M. (2011). *Logistics and supply chain management*. 4th ed., Financial Times Prentice Hall.

Chong, A. Y. L., & Chan, F. T. (2012). Structural equation modeling for multi-stage analysis on Radio Frequency Identification (RFID) diffusion in the health care industry. *Expert Systems with Applications, 39*(10), 8645-8654.

Delen, D., Hardgrave, B., & Sharda, R. (2007). RFID for better supply-chain management through enhanced information visibility. *Production and Operations Management*, *16*(5), 613-24

Dubois, A., & Gadde, L.E. (2002). Systematic combining: an abductive approach to case research. *Journal of Business Research*, *55*(7), 553-560

Faber, N., de Koster, M. B. M., & Smidts, A. (2013). Organizing warehouse management. *International Journal of Operations and Production Management*, *33*(9), 1230–1256. https://doi.org/10.1108/IJOPM-12-2011-0471

Finkenzeller, K. (2010). *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication*. John Wiley and Sons, ISBN: 978-0-470-69506-7.

Gaukler, G.M., & Seifert, R.W. (2007). *Applications of RFID in supply chains. in Trends in Supply Chain Design and Management*. Springer, London, 29-48.

Garrido Azevedo, S., & Carvalho, H. (2012). Contribution of RFID technology to better management of fashion supply chains. *International Journal of Retail and Distribution Management*, *40*(2), 128-156.

García, A., Chang, Y., Abarca, A., & Oh, C. (2007). RFID enhanced MAS for warehouse management. *International Journal of Logistics*, 10(2), 97-107.

Ghazal, T. M., Alshurideh, M. T., & Alzoubi, H. M. (2021, June). Blockchain-Enabled Internet of Things (IoT) Platforms for Pharmaceutical and Biomedical Research. *In The International Conference on Artificial Intelligence and Computer Vision (pp. 589-600). Springer, Cham.*

Gu, J., Goetschalckx, M., & McGinnis, L.F. (2007). Research on warehouse operation: a comprehensive review. *European Journal of Operational Research*, *177*(1), 1–21.

Hamadneh, S., Pedersen, O., & Al Kurdi, B. (2021). An Investigation of The Role of Supply Chain Visibility into The Scottish Blood Supply Chain. *Journal of Legal, Ethical and Regulatory Issues*, *24*, 1-13.

Hasan, O., McColl, J., Pfefferkorn, T., Hamadneh, S., Alshurideh, M., & Kurdi, B. (2022). Consumer attitudes towards the use of autonomous vehicles: Evidence from United Kingdom taxi services. *International Journal of Data and Network Science*, *6*(2), 537-550.

Jarugumilli, S., & Grasman, S.E. (2006). RFID-enabled inventory routing problems. *International Journal of Manufacturing Technology and Management, 10*(1), 92-105.

Joghee, S., Alzoubi, H. M., Alshurideh, M., & Al Kurdi, B. (2021, June). The role of business intelligence systems on green supply chain management: Empirical analysis of FMCG in the UAE. *In The International Conference on Artificial Intelligence and Computer Vision* (pp. 539-552). Springer, Cham.

Kiefer, A.W., & Novack, R.A. (1999). An empirical analysis of warehouse measurement systems in the context ofsupply chainimplementation. *Transportation Journal*, 38(3), 18-27.

De Koster, M.B.M., Le-Duc, T., & Roodbergen, K.J. (2007). Design and control of warehouse order picking: a literature review. *European Journal of Operational Research*, *182*(2), 481-501.

Kgobe, P., & Ozor, P. A. (2021). Integration of radio frequency identification technology in supply chain management: A critical review. *Operations and Supply Chain Management*, *14*(4), 289–300. https://doi.org/10.31387/oscm0460303

Lee, K., Azmi, N., Hanaysha, J., Alshurideh, M., & Alzoubi, H. (2022a) The effect of digital supply chain on organizational performance: An empirical study in Malaysia manufacturing industry. *Uncertain Supply Chain Management*, *10*(2), 1-16.

Lee, K., Ramiz, P., Hanaysha, J., Alzoubi, H., & Alshurideh, M. (2022b) Investigating the impact of benefits and challenges of IOT adoption on supply chain performance and organizational performance: An empirical study in Malaysia. *Uncertain Supply Chain Management, 10*(2), 1-14.

Li, S., Godon, D., & Visich, J. K. (2010). An exploratory study of RFID implementation in the supply chain. *Management Research Review*, *33*(10), 1005–1015. https://doi.org/10.1108/01409171011084003

Lim, M. K., Bahr, W., & Leung, S. C. H. (2013). RFID in the warehouse: A literature analysis (1995-2010) of its applications, benefits, challenges and future trends. *International Journal of Production Economics*, *145*(1), 409–430. https://doi.org/10.1016/j.ijpe.2013.05.006

Mabad, T., Ali, O., Ally, M., Wamba, S. F., & Chan, K. C. (2021). Making Investment Decisions on RFID Technology: An Evaluation of Key Adoption Factors in Construction Firms. *IEEE Access*, *9*, 36937–36954. https://doi.org/10.1109/ACCESS.2021.3063301

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics*, *22*(2), 1-25.

Myers, M. D., & Newman, M. (2007). The qualitative interview in IS research: Examining the craft. *Information and Organization*, *17*(1), 2–26.

Ngai, E.W.T., Moon, K.K., Riggins, F.J., & Candace, Y.Y. (2008). RFID research: An academic literature review (1995–2005) and future research directions. *International Journal of Production Economics*, *112*(2), 510-520.

Nuseir, M. T., Al Kurdi, B. H., Alshurideh, M. T., & Alzoubi, H. M. (2021, June). Gender Discrimination at Workplace: Do Artificial Intelligence (AI) and Machine Learning (ML) Have Opinions About It. *In The International Conference on Artificial Intelligence and Computer Vision* (pp. 301-316). Springer, Cham.

Ramaa, A., Subramanya, K. N., & Rangaswamy, T. M. (2012). Impact of warehouse management system in a supply chain. *International Journal of Computer Applications*, *54*(1), 14-20

Ryan, A., Tähtinen, J., Vanharanta, M., & Mainela, T. (2012). Putting critical realism to work in the study of business relationship processes. *Industrial Marketing Management*, *41*(2), 300–311

Öztayşi, B., Baysan, S., & Akpinar, F. (2009). Radio frequency identification (RFID) in hospitality. *Technovation*, *29*(9), 618-624.

Rim, S.C., & Park, I.S. (2008). Order picking plan to maximize the order fill rate. *Computers & Industrial Engineering*, *55*(3), 557-566.

Rouwenhorst, B., Reuter, B., Stockrahm, V., Van Houtum, G.J., Mantel, R.J., & Zijm, W.H.M. (2000). Warehouse design and control: framework and literature review. *European Journal of Operational Research, 122*, 515–533.

Sarac, A., Absi, N., & Dauzère-Pérès, S. (2010). A literature review on the impact of RFID technologies on supply chain management. *International journal of production economics*, *128*(1), 77-95.

Shamout, M., Ben-Abdallah, R., Alshurideh, M., Alzoubi, H., Kurdi, B., & Hamadneh, S. (2022). A conceptual model for the adoption of autonomous robots in supply chain and logistics industry. *Uncertain Supply Chain Management*, *10*(2), 577-592.

Svoboda, P., Ghazal, T. M., Afifi, M. A., Kalra, D., Alshurideh, M. T., & Alzoubi, H. M. (2021, June). Information Systems Integration to Enhance Operational Customer Relationship Management in the Pharmaceutical Industry. *In The International Conference on Artificial Intelligence and Computer Vision* (pp. 553-572). Springer, Cham.

Småros, J., Holmström, J., & Kämäräinen, V. (2000). New service opportunities in the e-grocery business. *The International Journal of Logistics Management*, *11*(1), 61-74.

Tariq, E., Alshurideh, M., Akour, E., Al-Hawaryd, S. and Al Kurdi, B. (2022b) The Role of Digital Marketing, CSR Policy and Green Marketing in Brand Development at UK. *International Journal of Data and Network Science*, *6*(3), 1-10.

Tariq, E., Alshurideh, M., Akour, I., & Al-Hawary, S. (2022a). The effect of digital marketing capabilities on organizational ambidexterity of the information technology sector. *International Journal of Data and Network Science*, *6*(2), 401-408.

Want, R. (2006). An introduction to RFID technology. *IEEE Pervasive Computing*, *1*, 25-33.

Yin, R. (1994). *Case study research: Design and methods*, 2nd ed. Thousand Oaks, CA: Sage Publications

Yin, R.K. (2009). *Case study research: design and methods*, 4th ed., Sage, California.

Appendix 1

Interview guide

Section 1: General questions

What is your position concerning warehouse management?

How long have you been working for this company?

Section 2: Main interview questions:

1. In your opinion, what is the value of RFID for the company?

2. Does it make your job easier/difficult? Explain?

3. Do you think that you can realize the full potential of RFID? Why?

4. How does it affect your work?

5. Have you observed any changes after RFID implementations when fulfilling customers' orders?

6. Was it easy to adapt to the system? Describe…

7. How was the process of implementation in terms of adoption?

8. What kind of changes did you observe after implementations in the warehouse?

9. Could you explain the decision and implementation process of RFID?

10. What kind of challenges have you experienced during the implementation?

11. If it is decided to upgrade the system to a more advanced one, are you ready for that?