OPERATIONS AND SUPPLY CHAIN MANAGEMENT
Vol. 14, No. 3, 2021, pp. 289 – 300
ISSN 1979-3561 | EISSN 2759-9363

Integration of Radio Frequency Identification Technology in Supply Chain Management: A Critical Review

Palesa Kgobe
Department of Quality and Operations Management, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
Email: Palesa.kgobe13@gmail.com

Paul A. Ozor
Department of Quality and Operations Management, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
Department of Mechanical Engineering-Industrial Engineering and Management, University of Nigeria Nsukka, Nigeria
Email: pozor@uj.ac.za, paul.ozor@unn.edu.ng *(Corresponding Author)*

ABSTRACT

Innovative technological devices has gained popularity with many organisations in search of operations and quality improvements. Whilst the introduction of certain technologies in supply chain management (SCM) can enhance the speed of processes, provide improvement in accuracy and streamline information storage, others can result in product visibility, reduction in inventory and labour costs. This paper critically presents a terse account of Radio Frequency Identification Device (RFID) integration in SCM using literature review analytical research approach. The RFID is a useful tool for effective management of organisations' supply chain activities and global competitive competencies. The recorded performances are concisely analysed to display an outline of the possible spheres and benefits of RFID adoption. Reports from series of authors claim general acceptability and profitability, to an extent that precludes the invitation of any scepticism. As much as there are key issues identified during RFID technology adoption and utilization, consideration of the driving factors branded by some global organisations was fulfilled. Various approaches and concerns associated with incorporation of RFID by many organisations in SCM were provided. This forms part of an aid in drawing meaningful conclusions about the impact, status and future direction of RFID on SCM.

Keywords: *RFID technology, RFID integration, supply chain management, performance improvement*

1. INTRODUCTION

In today's world, global competition, technological innovations, short product life cycle and constant industrial revolution, especially information technology (IT) advances have transformed the business "*modus operandi"* of companies. Specifically, information technology has been adjudged the operative resolution to supply chain problems confronting companies due to overarching increase in materials and information flow in the SCM (Huddiniah and ER, 2019). Companies have turned to redesigning business processes and innovating competitive products and services. Change is an inevitable constituent in the lifecycle of any business irrespective of how successful it has been in the past (Ahmed and Kouba, 2013). Market globalisation has further spurred more competition in the provision of best quality products and services. Accordingly, customers' satisfaction demands and the all-encompassing intention to thrive profitably in the local and global marketplace necessitates the implementation of new SCM technologies (Hu and Haddud, 2017). Kamalapur and Lyth (2020) present a proof of concept study to explore the effect of two compensation strategies on supplier's returns and retailer's gains in an e-commerce drop-shipping supply chain environment with the aid of simulation modelling. Even so, organisations will need to drive continual innovation throughout business operations to create distinct qualities that can ward off threatening competitors. The proficiency of meeting customer requirements, for everything from coffee beans to shoes, is built upon the expectation that everything should be carried out within the supply chain properly. Subsequently, customers can buy an experience and not just a product or service (Schallehn *et al.*, 2019; Zhang *et al.*, 2019; Prentice *et al.*, 2019; Van der Meulen, 2018; Wu and Zhu, 2017). Therefore, a good product or service will not easily make up for an unpleasant experience.

A vast amount of disappointment in SCM can stem from late delivery. Some authors opine that issues associated with late delivery can potentially lead to loss in customer goodwill while an accelerated conveyance can bring satisfaction and retain the customer (Kohler *et al.*, 2019; Kogan *et al.*, 2018; Han *et al.*, 2017). Another important factor that affects customers' behaviour in SCM field is individual experiences. For instance, the Council of Supply Chain Management Professionals (CSCMP) maintains that SCM is an integral part of the operational efficiency of most businesses. According to the American Production and Inventory Control Society (APICS, 2019), optimal collection and deliveries are essential to the success of the company and

customer satisfaction. The Professionals lend credence to past researchers that attempted a general and specific definitions for SCM (Farooque *et al.*, 2019; Ellrama and Murfield, 2019; Heckmann *et al.* 2015; Lambert, 2014; Ahi and Searcy, 2013). In particular, Ahi and Searcy (2013) chronicle most of the published definitions associated with green SCM and sustainable SCM. Whatever meaning that is adopted, an SCM strategy should be capable of creating or sourcing and managing the movement of data, machines, materials, man, resources, finances etc., from one point- probably an origin or warehouse(s) to a destination- probably a purchase or consumption point. The management must also be done in a manner that represent good value and profit to all players. In a non-technical language, SCM is basically the manner in which a business manages the way goods and services move from production centres to consumption points.

In the past, SCM appeared simple when factories activities were mainly of a routine nature and largely under the whims and caprices of human intellect. More recently, Organisations responsibilities have become more complicated, compelling obvious and rapid changes in SCM administration. This stride is further driven by a global business movement towards digitisation. Nayak *et al* (2015) warn that the breakneck speed at which technological developments are being introduced in the world posed a prospective challenge to the enterprise, retailer, and supplier. Barloworld Logistics (2017), which agree that the current digital trends are disrupting traditional supply chain management, supports the author. Hence, companies regardless of size seek ways to transform SCM functions. The objectives of SCM includes creating net value, leveraging worldwide logistics and building a competitive infrastructure. Others are harmonizing supply chain expectations and global measuring performances through conception, coordination, planning, implementation and monitoring of supply chain activities (Fowler *et al.,* 2019; Jia *et al.,* 2019; Kshetri, 2018; Lambert, 2014). Managing the flow of such activities requires a balancing art amongst competing interests, which can be very intensive.

Accordingly, many businesses across the world are investing in supply chains and implementing innovative technologies that allows real-time information sharing (Wei *et al.*, 2019; Raweewan and Ferrell, 2018). Appropriate data sharing in SCM can drive efficiency, reduce costs and promote strategic growth (Bastas and Liyanage, 2019; Derry, 2019; Tseng *et al.*, 2019; Wantao *et al.*, 2018). RFID technology is a typical data gathering and recording and sharing tool that can ease significant processes in SCM. The technology is not altogether new. Upfold and Lui (2009) report that the first use of the technology goes as far back as the Second World War. At the time, fighter planes employed RFID to uniquely distinguish between own planes and that of the enemies (Crepaldi and Pimenta, 2017). The system was then referred to as the Identification of Friend or Foe (IFF) arrangement (Sarac *et al.,* 2010). In its functionality, RFID employ a wireless system of communication that utilises various radio frequencies to automatically identify objects or people with unique tags (Dukyil *et al.*, 2018; Hunt *et al.*, 2007). Recently, Duroc and Tedjini (2018) clarify that the entire system is basically a remote identification structure which easily uses radio waves of different frequencies to transmit information between two sources without human intervention. Today, RFID is classified among the technologies gaining popularity in many organisations as a solution to the effective management of supply chain activities (Nayak, 2019; Dimakopoulou *et al.*, 2014; Sari, 2010; Ustundag and Tanyas, 2009). Given the above, RFID technology provides a service that is capable of revolutionising the way organisations track products. Walmart and the US Department of Defence share the first successful commercial adopters of the technology in the early 2000's (Visich *et al.*, 2009). Companies such as Target, Tesco, Michelin and Metro Group to name a few, followed suit (Fan *et al*., 2015).

Sarac *et al* (2010) had reviewed the impact of RFID on SCM while Chang *et al.* (2010) determine the optimality criterion. About the same period, the characteristics of RFID ranging from excellent data security, high storage capacity, multiple-tag reading and remote access, were explored. A past literature advocate establishment of a working framework for RFID implementation within logistics and SCM (Lin, 2009). The author rely on issues of inventory optimality, speeding up processes and information accuracy to elucidate the impacts of RFID on different SCM schemes. The logistic processes implemented in air cargo operations and consolidation activities is a typical area of application of RFID technology. Giust *et al.* (2019) use the technology to address the quality issues in air cargo logistic processes ranging from freight receipt, security control and freight storage that occur in a warehouse, and haulage to boarding in airport. The technology has afterwards gained the attention of many researchers (Pal, 2019; Biswal *et al.*, 2018, Zhang *et al.*, 2018). Specifically, presentations bordering on logistics and SCM including risk factors are well documented in literature (Gautam *et al.*, 2017, Fan *et al.*, 2015, Chen *et al.*, 2014, Chen *et al.*, 2013). The problems occasioned by inventory inaccuracies can deter the achievement of organizations set goals and customers' expectations. Curbing the challenges can trigger specific detailing of application of RFID strategies in warehousing and inventory aspects of SCM (Cui *et al.*, 2017). For example, Duroc and Tedjini (2018) reveal vast area of application of RFID in over hundred countries. To fully reap the gains of the technology, the application must align properly with the scenario of its exploration. This is particularly very important as wrong results from the RFID scheme can reduce its popularity and discourage future intending users (Tu *et al.*, 2018; Leung *et al.*, 2014).

This study appropriately acknowledges the existence of a past publication on the review of the framework for assessing data quality and performance in the health sector (van der Togt *et al.*, 2011). A more SCM-closer overview of the current and imminent RFID technologies is also in literature (Ilie-Zudor *et al.*, 2011). The two studies succeed the chronicle of publications on the impact of RFID in SCM reported a year earlier (Serac *et al.,* 2010). Other researchers had devoted good effort in presenting summary of published articles on RFID (Wamba *et al.,* 2013, Peppa and Moschuris, 2013). Since 2013, there is no other report of any research output bordering on articulating a compendium of works that have featured in the area of RFID vis-à-vis SCM and its corollaries known to the authors. This is with reference to the effort of several researchers that have continued to labour in other aspects of RFID technology (Lee *et al.,* 2019; Tran *et al.,* 2019). A significant amount of such publications is

reviewed in this study. The paper is essentially an attempt to bridge the obvious gap following the absence of summary of recent research efforts in RFID technology. Without any loss of generality in reviewing the RFID schemes in most aspects of SCM, the paper focuses on the possible benefits, key issues and the financial impact of RFID technology application to SCM within the last seven years. The authors attempt to elaborate on the challenges and uncertainties, as well as the benefits pertaining to exploration of RFID technology on SCM. The paper further estimates possible future trends and perspectives of RFID in the supply chain sector.

2. BRIEF OVERVIEW OF RFID TECHNOLOGY

The RFID systems belong to a group of technologies categorised as Automatic Identification and Data Capture (AIDC) devices. The RFID technology is a wireless communication that permits computers to decipher the distinctiveness of economical electronic tags from a distance (Nath *et al.*, 2006). The technology basically works by sending radio waves or signals between two objects: technically, a reader and a tag. Hence, it is considered an enabling technology (Yusof and Saman, 2016). The potential advantages of the technology have spurred significant number of researchers to embark on investigations in RFID phenomena (Li *et al.*, 2010). For instance, Wamba *et al* (2013) reveal that the technology has captivated the imagination of academics and practitioners due to its proclivity and tactical potential for revolutionizing SCM operations. The RFID on its own does not provide much value, but makes it possible for organisations to develop an application data processing system that creates value. The application system is a data processing structure that forms part of the three main components that make up an RFID system (Ji *et al.,* 2012). The first component houses the RFID tags (transponders), which are constituted by a chip connected with an antenna. An RFID reader (interrogators) make up the second component. The interrogators releases radio waves and admits data from the tags. Finally, an application software that processes the received data (Nayak *et al.*, 2015, Masum *et al.*, 2013) form the third module. **Figure 1** presents an illustration of an RFID system.

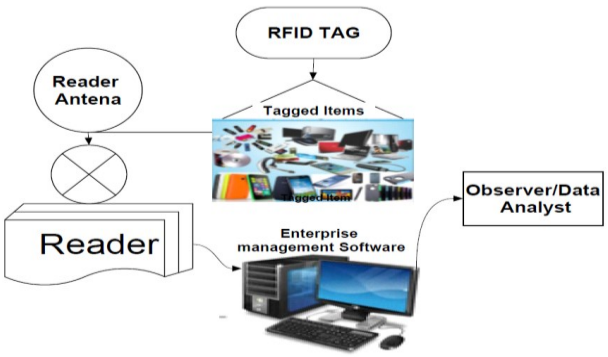

Figure 1 Basic Components of an RFID System
(Source: This work)

An RFID system allows for a quick, flexible, and reliable way for electronically detecting, tracking and controlling a variety of items or objects (Ruan *et al.*, 2018). Peppa and Moschuris, (2013) laboured on the effects RFID technology has in supply chain management. The authors show that the basic functionality of an RFID system is to assist in identifying, alerting, monitoring, authenticating and locating as well as controlling processes, people and products. This view is in agreement with earlier report on the concept (Mall and Mishra, 2012). As a result, subsequent researchers elaborated on the application of RFID technology in many production, manufacturing and distributing operations (Yang *et al.*, 2016, Alyahya *et al.,* 2016; Roselli, 2014). The RFID largely possess the potential to improve accuracy and speed up information retrieval (Lopez *et al.*, 2018). Nowadays, RFID is widely used across many sectors and its applications are numerous and far reaching to list all. Nonetheless, the most successful applications in the opinion of Ji *et al.* (2012) include production process control, objects tracking management and supply chain management. On the contrary, Mall and Mishra (2012) reported security, access control, retailing, supply chain management and manufacturing along with asset tracking as the leading applications of RFID technology.

3. RESEARCH METHODOLOGY

The RFID literature is spread in diverse ways in form of bulletins, book chapters, Journal articles, conference proceedings, company reports and others. To achieve the objectives of this research, peer reviewed articles published in very high impact factor Journals took a large chunk of the materials used. The rest of the sourced materials are divided among conference proceedings, bulletins, book chapters and company reports. In particular, the attention was focused on international journals and peer reviewed conference proceedings as well as published book chapters. There is strong assurance that most of the materials used passed through a rigorous peer review process that is independent of any sentiment. The editors' popularity and Journal recommendation for publication of research outputs from established researchers also informed the choice of selection. The journals that are recommended by the South Africa Department of Higher Education and Technology (DHET) were preferred as most were indexed by reputable international repositories which includes but not limited to Thompson Reuters, Scopus, ISI, SNIP, SCIMAGO etc. Only the international conference publications that are strictly concerned with the topic were used. The ability of such conferences to have survived a long lasting and unbroken refereeing processes were relied upon during selection. **Figure 2** presents the distribution of material sources used for the research. Another area of concern was the reference period. Preliminary investigations revealed that research in RFID application to SCM has not been growing as earlier expected. Therefore, we stretched the period as far back as 2006 to properly capture the trend. In doing this, care was exercised to omit most of those works that have already been reviewed and published by previous authors (Wamba *et al.*, 2013, Peppa and Moschuris, 2013, Serac *et al.*, 2010). **Figure 3** shows the period versus number of materials sourced. The distribution is basically from 2006 to 2019.

The research first introduce the RFID system and attempt to summarize past efforts as well as set the case for this research. In the preceding section, a brief overview of RFID technology in SCM was presented. Subsequently the application in SCM is discussed. The possible benefits and

key issues as well as current and short-term challenges facing the technology is presented. The major concerns expressed by researchers regarding full integration of RFID into supply chain management is summarised. Next, the paper enumerates some of the impact which RFID implementation has on profitability of SCM. The section also addresses the financial impacts of deploying the technology in supply chain management. In section five, some approaches proposed for evaluating and dealing with some of the challenges and key issues encountered within the ambience of RFID technology implementation in supply chain management is presented. The paper ends with a conclusion and recommendation for future work, drawn from the realities of the reviewed publications.

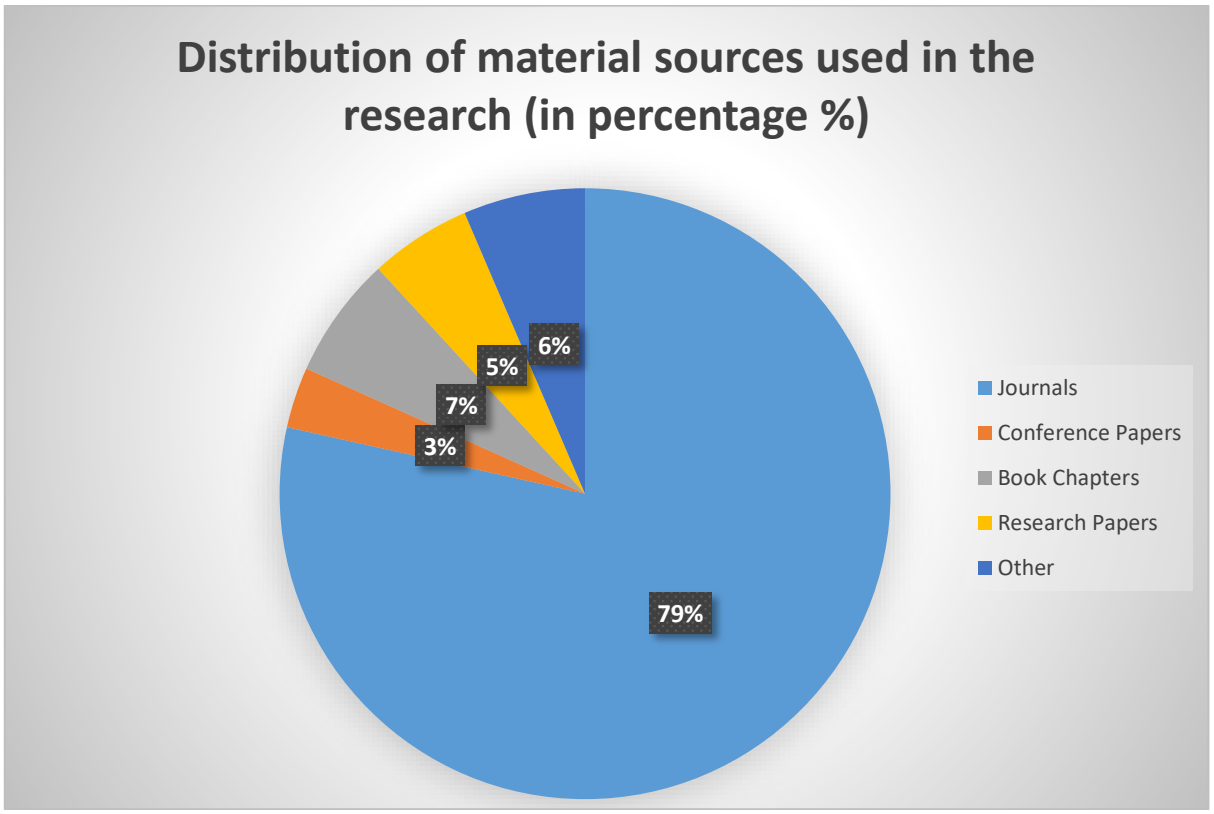

Figure 2 The distribution of material sources used in the research

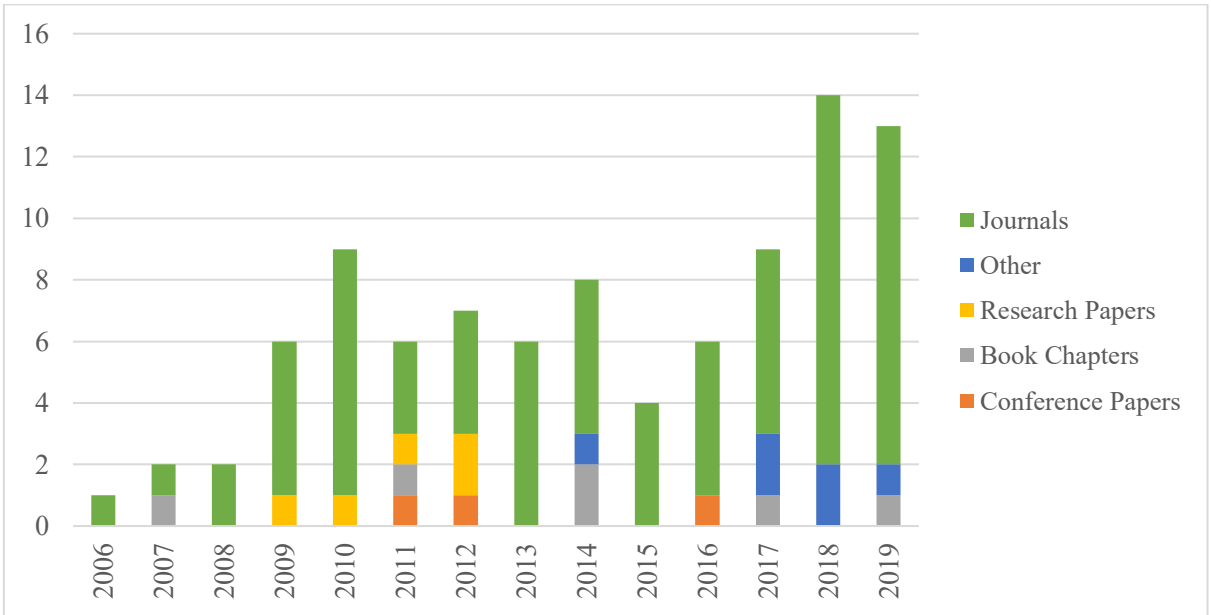

Figure 3 Materials sourced according to year

4. RFID INTEGRATION IN SCM

Haddud (2011) maintain that companies opt for RFID technology in supply chain activities to promote efficiency and optimise business operations. Ali (2012) added that the supply chain represents a very important, thrilling and significant development potential for the use of RFID to which Peppa and Moschuris (2013) expressed no surprises at all. Many companies are adopting new technologies and innovations with the aim of achieving a competitive advantage, therefore RFID technology is for all intents and purposes. The underlying fact is that organisations are seeking to optimize SCM capabilities (Peppa and Moschuris, 2013). In addition, Leung *et al* (2014) stated that RFID technology possesses the promise of reforming SCM by offering spontaneous actual supply chain perceptibility. In pursuance of the above, several instances of leading organisations that make use of RFID solutions for various processes in the Supply chain management is available in Tajima (2007). Additionally, Nayak (2019) instils that the driving factors for the adoption of this technology are accuracy in inventory management and information; efficiency in traceability; reduced time and labour costs; prevention of loss and theft as well as product visibility to name a few. The succeeding section bestows a comprehensive description of the potential benefits of adopting, implementing and/or integrating RFID technology in SCM. The key issues that have been raised in the past fourteen (14) years regarding RFID and its application in supply chain are revised.

4.1 Potential Benefits of RFID in Supply Chain Management

A properly implemented RFID system can create abundant benefits for an organisation and its supply chain (Nash, 2010). The technology can offer various supports to SCM. For example, it present innovative aids that can enhance products identification, seamless communication and information access simultaneously (Masum *et al.*, 2013; Sarac *et al* (2010). Tsai and Tsang (2012) postulate that RFID can facilitate the exchange of necessary information in real-time and assist in strengthening good communication amongst supply chain members. The RFID can synchronise data and achieve smooth physical goods as well as commodities flow across the supply chain, beginning with the manufacturers, wholesalers and retailers alike. The flow can continue until the final customers or consumers are satisfied (Nash, 2010). In a related development, Gale *et al.* (2009) report that implementing RFID technology in SCM can magically transform storage visibility and provide both precise and timely data on the supply-demand relationship. The authors conclude that the key issues can increase the profitability of organizations' supply chain performance at almost all levels, including financial aspects. Essentially, RFID helps both in increasing the accuracy of inventories and reducing inventory time consumption. According to Finley (2014), Mechanical approaches to inventory taking can be laborious and weakening. It is not just time consuming, but can be misleading due to inaccurate counting and recording. Consequently, the RFID alternative is preferred when the objective is to reduce, if not totally eliminate the need for hand-scanning or hand-counting. The immediate and remote advantages of inventory tracking which can influence customers' experiences and quality service is already in literature (van der Meulen, 2018). The presentation insist that a proficient tracking can at worst eliminate unwarranted errors and reduce out-of-stock frequency for the organization. Ultimately, this can lead to profitability due to increased sales and a reduction in loss prevention costs. Additionally, the technology facilitates logistics efficiency in supply chain management and improves productivity by reducing labour costs and product cycle time (Haddud, 2011). Considering that RFID in SCM decrease errors in manual work, the amount of defects and reworks are subsequently reduced and as a result, there will be higher quality of the product and services (Attaran, 2012). According to Lusk (2017), the provision of real-time data and analytic procedures made possible through RFID technology allows organisations to be more accurately informed and make better decisions regarding supply chain management. This can allow for improved utilisation of resources; better-quality data sharing within a given organization and among different supply chains, despite minimizing operating costs and consolidating competitive advantages.

RFID implementation can contribute significantly to managing supplier relationship within the supply chain management processes. To clarify further, Shaikh *et al* (2014) stated that the ability of the technology to collect, gather and track information about all materials and products moving across the supply chain will allow suppliers to control the level of communication and information sharing. Furthermore, supplier can share data with buyers and customers in real-time. In summation, the benefits of RFID technology in Supply chain management remain endless. It can assist in radically lessening business overheads, depending on how correctly the technology is implemented (Upfold and Lui, 2009). The technology does indeed guarantee labour reduction, precise management, prevention of loss and theft, efficiency in inventory management (Dolgui and Proth, 2008) and increased product visibility. Thus resulting in a reduction in production costs. Although there are many benefits that will result from the adoption of RFID technology, equally many challenges and concerns need to be overcome.

4.2 Critical Aspects (Key **I***ssues) of RFID in SCM*

As with most technologies, RFID has unfortunately present with evident limitations and concerns that can hinder its adoption or deployment, if not properly addressed and managed. Owunwanne and Goel (2010) stated that the technology has some issues militating against its success and exponential growth in many organisations. Chuang (2017) concurred with the authors by stating that some specific hindrances must be overcome for the potential benefits, which RFID technology has in store to hold sway. In that perspective, Darcy *et al* (2011) postulated that the challenges of implementing the technology in supply chain management include most of the issues as proposed by Angeles (2005): reliability and accuracy issues; cost issues; system execution efficiency, electromagnetic interference problems, privacy concerns and lack of global standardisation. Similarly, Attaran (2012) argue that RFID technology faces enormous implementation deficiencies, which can broadly be distinguished into internal and external impediments. Integration issues, high capital with low rate of recouping

initial investments can constitute the internal challenges, whereas the external difficulties were mainly of security concerns, reliability, privacy and paucity of regulation and standardisation. From the foregoing, challenges commonly faced when implementing RFID technology in not just the SCM, but operations of any business can be identified. The most significant challenges are categorized as implementation cost; technology incompatibilities; availability to resources, commitment, security and privacy, standardisation and government regulations.

Conversely, the desire to reduce and/or cut costs throughout the entire supply chain management has led multiple organisations to thinking in the direction of incorporating RFID technology (Smart *et al.,* 2010). Therefore, the next section stipulates a brief outline of the impact RFID technology implementation has on profitability in the Supply chain management.

4.3 Financial Impact of RFID in Supply Chain Management

It is very important to determine the financial impact of implementing RFID in the SCM of any business. **Table 1** shows a summary of the challenges faced during RFID implementation. However, knowledge growth and implementation realities has further exposed other concerns not captured in the **Table 1**. More of the issues that has cropped up are discussed in subsequent sections.

Table 1 RFID Implementation Challenges. Source: Attaran (2012)

Different Levels	Possible Difficulties
Fundamental Issues	• Prohibitive Capital • Low rate of recouping capital • Generating adoption interest
Technical Issues	• Inaccuracies in Read-rates • System Validation issues • Presence of low-cost tags • Indecision about middleware role • Lack of RFID implementation resources (human)
Security Problems	• Compromise-ability of data • Data storage confidentiality concerns • physical security uncertainties around site for data storage
Privacy Concerns/ Government Regulations	• Unguaranteed privacy • Litigation possibilities • Standards uncertainties

When an organisation cannot capture data properly; has an inefficient process; a low traceability rate of item and an unintegrated system, it is bound to experience billing delays; loss of sales; slow production; stock outs and delayed shipment. This is because the organisation cannot manage its supply chain activities. According to Mall and Mishra (2012), an effective supply chain management has the capabilities of producing planning solutions and helping in taking strategic level decisions. Accordingly, an ineffective supply chain management can be the downfall of any business. Given the above, in the early 2000s, for instance; Nike installed an "improved inventory management software" to manage supply chain. Unfortunately, the inventory software implementation failed, causing an overproduction of products and as a result, the lack of inventory control at Nike led to the loss of approximately $100 million in sales (Waller and Conaway, 2010). The Nike case just illustrates how crucial it is for any organisation-big, medium and small to have an adequately functional inventory management system. In that context, the adequate application of RFID in the organisation's supply chain management can assist in preventing such a financial crisis.

When it comes to adopting or installing a new technology, Tsing *et al.* (2013) suggest that the organisation doing so should determine the return on investment (ROI). Sarac *et al.* (2010) delineates the importance of conducting ROI analysis to include evaluation of organizations investment profitability within some reference time scale. Yet, a study conducted by Lee and Lee (2010) lament that most of the hitherto-used financial and accounting methods, for instance; net present value (NPV) and ROI, have not vindicated the need for integrating RFID scheme into the organizations investment prospects. This might probably be due to seeming intangible nature of many identified RFID benefits. On the contrary, De Souza *et al* (2011) propose the use of a "Supply Chain Operations Reference" (SCOR) model for RFID enabled supply chain in order to do ROI analysis and reap the benefits. Even so, Shin and Eksioglu (2014) revealed that it is unknown as yet whether the adoption of the RFID does contribute to the profitability in supply chain management despite the fact that it does reduce the number of days products stay as inventories.

Having said that, RFID enables organisational capabilities and efficient coordination with supply chain partner which leads to the improvement of operational and financial performance of companies (Janssens, 2016). The financial impact of implementing RFID in the supply chain management of any business can exist in the following areas (Sarac *et al.*, 2010; Smart *et al.*, 2010):

1. Reduction in stock-out rates evident in RFID integration can improve revenue and visibility.
2. There can be visible gains in operating margins due to the possibility of labour costs stability, write-offs, returns management etc. and optimized cost of carrying inventory.
3. There promises to be improvement in capital effectiveness resulting from elimination of barcoding equipment and reduction of property, plant and inventory costs.

As mentioned earlier, the potential benefits of RFID are numerous and so are the potential pitfalls. Therefore, if an organisation's ultimate objective is to obtain profits in terms of revenue and customer satisfaction, then the organisation might need to overcome the established challenges in pursuance of acquiring the optimised benefits from RFID.

5. DIFFERENT APPROACHES TO EVALUATE THE KEY ISSUES AND CHALLENGES OF RFID IN SCM

There exist a number of techniques suggested by researchers on how to tackle the issues and challenges in implementing a successful RFID in organizations. **Table 2**

categorize the references according to the different approaches suggested for evaluating the key issues and challenges, especially the works bordering on implementation cost (IC), unclear return of investment (uROI) and technology incompatibilities (TI).

Table 2 Categorization of References based on IC, uROI and TI

Key Issues/ Challenges (Problem)	Evaluation Approach (Solution)	References
Implementation Cost	• The system is automatic so there will be less labour force required. Therefore the cost to maintain RFID is not as high as the implementation cost • Cost-Benefit Analysis • Use simulation model such as Economic Order Quantity (EOQ) to calculate value before implementation	Ustundag and Tanyas, 2009; Nash, 2010; Smart *et al.,* 2010; Ali, 2012; Mall and Mishra, 2012
Unclear return of investment (ROI)	• Focus on the operational benefits as RFID benefits in SCM are unquantifiable • Cost-Benefit Analysis • SCOR Modelling • Perform Real Options analysis/valuation to evaluate technology investment • Technical difference between barcode and RFID impacts labour -reduced labour costs increases business capital • Thorough ROI analysis will indicate the worthy of deploying the technology • Higher cost tags bring investment value especial when there's severe shrinkage and misplacement	Ngai and Gunasekaran, 2009; Lee and Lee,2010; Usama and Ramish, 2020. De Souza *et al.,* 2011; Ilie-Zudor *et al.,* 2011 Ali, 2012; Chen *et al.,* 2013; Masum *et al.,* 2013; Chen *et al.,* 2014; Dimakopoulou *et al.,* 2014; Cui *et al.,* 2017 ; Biswal *et al.,* 2018
Technology Incompatibilities	• Business process redesign and reengineering • Integrate with existing systems • Sufficient technical support is required • Design a RFID middleware that is capable of addressing reliability issues, scalability, load balancing, security and data management	Lin, 2009; Attaran, 2012; Bhattacharya, 2012; Ji *et al.,* 2012; Nayak *et al.,* 2015;

Notable researchers posit that RFID plays a significant part in forward logistics. In particular, warehousing control and management, among other factors that add together to increase the responsiveness and cost efficiency of forward Supply Chains. Also, the technology provides product visibility and reduce lead-time in reverse logistics by increasing customer service levels (Usama and Ramish, 2020). However, from the perspective of Hinkka (2012), the different challenges and obstacles faced during RFID supply chain management implementation are interrelated. The author explains that purchasing more expensive technology and employing the assistance of external experts can solve most of the technological problems. Moreover, Yusof and Saman (2016) suggested that organisations should study the technology well, redesign the processes, develop suitable applications and make a careful pilot testing before utilising the RFID technology and putting the tags on materials and items in the Supply Chain Management.

Table 3 Categorization of References based on SEE, EI, TML and CC

Key Issues/ Challenges (Problem)	Evaluation Approach (Solution)	References
System Execution Efficiency	• Pilot study and testing prior to widespread implementation • Hire outside experts for assistance • Software configuration • Use computer based modelling simulation tools	Alyahya *et al.,* 2011; Attaran, 2012 ; Hinkka, 2012; Ting *et al.,* 2013
Electromagnetic Interference	• Study radio signals (frequencies) that exist in the neighbourhood where the RFID system will be deployed and avoid interference • Make use of Dense-reader mode (DRM) as the use of separate bandwidth strictly prevents interferences • Consider environmental factors and protect the environment around the reader with proper shielding	Rizve *et al.,* 2008; Ilie-Zudor *et al.,* 2011; Masum *et al.,* 2013; Ting *et al.,* 2013
Trouble with Metals and Liquids	• Employ the service of an Ecco pad device to boost the reading rate of tags placed near to metals • Adjust tag's location by placing it away from metal surfaces • Coat tags with an insulator	Ngai *et al.,* 2010; Rao *et al.,* 2011; Ting *et al.,* 2013
RFID Collision Course	• Employ an algorithm to eliminate anomalies found in the systems to correct the data before storing it • Employ various anti-collision algorithms such as Shadow Slot protocol and tree-based algorithm • Use scheduling-based reader collision avoidance methods	Darcy *et al.,* 2011; Reshma *et al.,* 2015; Wang *et al.,* 2016; Pal, 2019

The published literature on the challenges resulting from system execution efficiency (SEE), electromagnetic interference (EI) and trouble with metals and liquids (TML) as well as RFID collision course (CC) are presented in **Table 3**. A further categorization based on reliability and accuracy (RA), security (SEC), privacy and lack of standardization (PLS) are displayed in **Table 4**.

Table 4 Categorization of References based on RA, SEC and PLS

Key Issues/ Challenges (Problem)	Evaluation Approach (Solution)	References
Reliability and Accuracy	• Employ physical approaches to improve the tag reads such as: • Installing multiple readers • Install multiple antennas in a tag with different orientation • Customise the tag and antenna design for each item	Fan *et al.,* 2015; Gale *et al.,* 2007; Chen *et al.,* 2014; Nayak, 2019
Security	• Tag Deactivation and Encryption • Mutual Authentication • Use ambient conditions to operationalize authentication protocols • Detections in Tag Ownership • Reader analysis • Certain data cleaners • Employ querying protocols and jamming • Implement features Access rights	Darcy *et al.,* 2011; Ilie-Zudor *et al.,* 2011; Attaran, 2012; Wamba *et al.,* 2013; Shaikh *et al.,* 2014; Roselli; 2014; Yusof and Saman, 2016; Tu *et al.,* 2018
Privacy	• Use short-range, low energy readers • Carry around a privacy-enforcing RFID Device • General approaches of encrypting or rewriting and hiding or blocking tags • Killing or sleeping the tags	Darcy *et al.,* 2011; Ilie-Zudor *et al.,* 2011; Tsai and Tsang, 2012; Nayak, 2019
Lack of Standardisation	• Electronic Product Code (EPC) is still working with International Standards Organisation (ISO) to develop clearer standards • EPCglass 1 protocol and ISO 18000-6 can used • EPC Gen 2 suitable for supply chain • EPCglobal provides global standardisation	Owunwanne and Goel, 2010; Ilie-Zudor *et al.,* 2011; Shaikh *et al.,* 2014; Nayak *et al.,* 2015 Chuang, 2017

6. CONCLUSION

The status and integration of RFID technology in SCM undertaken in this research has significantly been attempted. The SCM scheme consists of planning and control of flow of goods and services from the origins through some intermediate centres and finally to the consumers (Shaikh *et al.,* 2014). Accordingly, research publications crisscrossing most of the SCM nodes were critically examined in this research. Today's era of globalisation and rapid technological advancements has resulted in many innovations that have inevitably impacted the traditional way businesses used to operate. With changes like these, organisations are inclined to keep up with the trends and global demands to sustain business, and keep generating profits. Amongst all the technologies that have developed in recent times, integration of RFID in the supply chain management system has had significant and positive impacts, with due regard to some of the attending discomfort. The RFID technology has an enormous opportunity for increasing value in a business by providing real-time tracking of information, product visibility, reducing operational margins, reducing out-of-stock items and increasing capital as well. The system remains globally competitive while considering SCM performance improvement. The technology has proved an efficient method to track inventory and potentially improve the SCM as a whole. Pioneer companies such as Walmart, Target, Tesco, Metro Group and Michelin to name a few, have undertaken developmental and confirmatory implementation, and the results are very impressive. In Supply chain management, the potential for the occurrences of devastating misconceptions such as not stocking to capacity, delivering to the wrong locations, losing product or a truck leaving a product behind etc. can cause large problems for the business. Most of the inherent problems can be avoided with RFID adoption. Therefore, it is undeniable that companies can scale up under the auspices of the technology and its contribution to the next era of industrial revolution and inventory management.

Despite the benefits, RFID does come with obstacles and concerns, which can be surpassed as long as the organisations that have or are planning to implement the technology are prepared to go beyond compliance. Consequently, miniature factors such as RFID adoption drivers being influenced by tag costs, product features and the difficulty to monetise the positive effects and advantages of the technology in the normal operation of the business has the potential to collapse the whole RFID adoption initiative. Additionally, the availability of the number of standards available for using RFID globally is limited. This was identified as a factor that could hinder the full benefit of implementing RFID technology in supply chain management, especially for organisations involved in importing and exporting goods. With the Electronic Product Code (EPC) still working with International Standards Organisation (ISO) to develop clearer standards (Owunwanne and Goel, 2010; Shaikh *et al.,* 2014) it is essential for organisations that have global supply chain to conduct further research to avoid compliance issues. Consequently, the value that RFID technology provides to organisation comes from improved processes and how well the technology and those processes are integrated with the enterprise (application) system. In the same perspective, the most effective RFID investment an organisation can do is to make use of experts to manage the RFID system design and implementation within the supply chain management.

Therefore, it can be established that the rich literature provided by this presentation proves that RFID continues to revolutionize supply chain management and can ensure profits to any organisation subject to proper design and implementation. If technology continues to advance this rapidly, then humans may be obsolete in supply chain because of "complete" automation. The status and integration

of RFID in the supply chain management undertaken in this presentation has satisfied its cleavage of delineating research efforts in the field within the reference period.

Considering reports from series of authors, which were critically analysed and displayed in this study, the RFID integration in SCM can at worst be described as having received general acceptability and its profit potentials to existing and emerging organizations is not in doubt. The reception it enjoys is up to an extent that precludes the invitation of any scepticism. As much as there are also key issues and challenges identified during RFID technology adoption and utilization, consideration of the driving factors branded by some global organisations was fulfilled in this research. Various approaches and concerns associated with implementation of RFID by many organisations in SCM have been included to further guide future researchers and organizations on the best choice path. While outright clairvoyance is neither claimed nor guaranteed, the presentation promises to be an interesting compendium for policy makers, researchers, and organizations. Research in RFID application to SCM has seemingly waxed from the beginning of 2018, but research outputs delving into warehouse inventory and storage improvements by RFID are still very scanty. In particular, application of RFID in management of warehousing systems have not received serious attention after the foundational feasibility study laid not very long ago (Alyahya *et al.,* 2016) and an attempt of real implementation during the following year (Cui *et al.*, 2017). We recommend a robust and profuse exploration of the RFID system in improving performance of Warehousing outfits as a lot of organizations stands to benefit from research dedicated to improving the sector.

REFERENCES

Ahi, P. and Searcy, C. (2013), A comparative literature analysis of definitions for green and sustainable supply chain management, *Journal of Cleaner Production,* 52 pp. 329 - 341

Ahmed, S.Z.F. and Kouba, M.B. (2013). Core Competencies and Phases of the Organisational life cycle, *International Journal of Business and Management Studies,* 5(1), pp. 461-473

Ali, O.M.S.H. (2012). Improved Supply Chain performance through RFID technology: Comparative case analysis of Metro Group and Wal-Mart. M.A. Dissertation. University of Wollongong, Available from: http://ro.uow.edu.ac/theses/3774 [Accessed 20 May 2019].

Alyahya, S., Wang, Q. and Bennett, N. (2016), Application and integration of an RFID-enabled warehousing management system – a feasibility study, *Journal of Industrial Information Integration,* 4, pp. 15–25

Attaran, M. (2012). Critical Success Factors and Challenges of Implementing RFID in Supply Chain Management, *Journal of Supply Chain and Operations Management,* 10, (1), pp. 144-167

Barloworld Logistics. (2017). Think Global Act Local: Technology Trends and South African Supply Chains. Supply Chain Foresight. Available from: http://www.barloworld-logistics.com/supplychainforesight-survey/ [Accessed 28 May 2019].

Bastas A., and Liyanage, K. (2019), Integrated quality and supply chain management business diagnostics for organizational sustainability improvement, *Sustainable Production and Consumption,* 17, pp. 11–30

Bhattacharya, M. (2012). Impact of RFID on the Retail Value Chain: An Exploratory study using a Mixed Method Approach, *Journal of Technology Management and Innovation,* **7**(4), pp. 36-49

Bergquist, B., Vanhatalo, E. (2020), In-situ measurement in the iron ore pellet distribution chain using active RFID technology, *Powder Technology*, 361, pp. 791 – 802

Biswal, A.K., Jenamani, M. and Kumar, S.K. (2018), Warehouse efficiency improvement using RFID in a humanitarian supply chain: Implications for Indian food security system, *Transportation Research Part E,* 109, pp. 205–224

Chang, S., Klabjan, D. and Vossen, T. (2010), Optimal Radio Frequency Identification Deployment in a Supply Chain Network, *International Journal of Production Economics,* 125, pp. 71–83

Chen, J.C., Cheng, C-H., Huang, P.B. (2013), Supply chain management with lean production and RFID application: A case study, *Expert Systems with Applications,* 40, pp. 3389–3397

Chen, S., Wang, H., Xie, Y. and Qi, C. (2014), Mean-Risk Analysis of Radio Frequency Identification Technology in Supply Chain with Inventory Misplacement: Risk-Sharing and Coordination, *Omega,* 46, pp. 86–103

Chuang, T. (2017). Challenges and Benefit Analysis of Adopting RFID in Supply Chain Management, *Journal of Global Business Management,* 13(1), pp. 37 - 49

Crepaldi, P.C. and Pimenta, T.C. (2017), Introductory Chapter: RFID: AA Successful History. In: Crepaldi, P.C. eds. Radio Frequency identification. Available from: https://doi.org/10.5772/intechopen.69602 [Accessed 27 May 2019].

CSCMP (2018). Supply Chain Management Concepts. Available from: https://cscmo.org [Accessed 04 June 2019].

Cui, L., Deng, J., Liu, F., Zhang, Y. and Xu, M. (2017), Investigation of RFID investment in a single retailer two-supplier supply chain with random demand to decrease inventory inaccuracy, *Journal of Cleaner Production,* 142, pp. 2028 - 2044

Darcy, P., Pupunwiwat, P. and Stantic, B. (2011). The Challenges and Issues Facing the Deployment of RFID Technology. In: Turuc, C. eds. Deploying RFID Challenges, Solutions and Open Issues, Available from: http://dx.doi.org/10.5772/16986 [Accessed 04 June 2019].

De Souza, R., Goh, M., Sundarakani, B., Wai, W.T. and Yong, W. (2011). Return on Investment Calculator for RFID Ecosystem of High Tech Company, *Computers in Industry,* 62(8-9), pp. 820 - 829

Derry, T. (2019). Institute of Supply Management: Supplier Relationship Management in the Digital Supply Chain. Available from: https://www.supplychaindigital.com/SCM/institute-supply-management-supplier- [Accessed 20 May 2019].

Dimakopoulou, A.G., Pramatari, K.C. and sekrekos, A.E. (2014), Applying real options to IT investment evaluation: The case of radio frequency identification (RFID) technology in the supply chain, *International Journal of Production Economics,* 156, pp. 191–207

Dolgui, A. and Proth, J.M. (2008). RFID Technology in Supply Chain Management: State-of-the-Art and Perspectives, *International Federation of Automatic Control (IFAC papers Online),* 41(2), pp. 4464 - 4474

Dukyil, A., Mohammed, A. and Darwish, M. (2018). Design and Optimisation of an RFID-Enabled Passport Tracking System, *Journal of Computational Design and Engineering,* 5(1), pp. 94-105

Duroc, Y. & Tedjini, S. (2018). RFID: A key Technology for Humanity, *Radio Science for Humanity,* 19 (1-2), pp. 64-71

Ellrama, L.M. and Murfield, M.L.U. (2019), Supply Chain Management in Industrial Marketing–Relationships Matter, *Industrial Marketing Management,* 79, pp. 36–45,

Fan, T., Tao, F., Deng, S. and Li, S. (2015). Impact of RFID Technology on Supply Chain Decisions with Inventory

Inaccuracies. *International Journal of Production Economics,* 159(1), pp. 117-125,

Farooque, M., Zhang, A., Thurer, M., Qu, T. and Huising, D. (2019), Circular Supply Chain Management: A Definition and Structured Literature Review, *Journal of Cleaner Production,* 228 pp. 882-900,

Finley, J. (2014). 5 Benefits of Using RFID in Manufacturing and Supply Chain Management. Available from: http://sickusablog.com/5-benefits-of-using-rfid-in-manufacturing-and-supply-chain-management/ [Accessed 03 June 2019].

Fowler, J.W. Kim S.-H. and Shunk, D.L. (2019), Design for customer responsiveness: Decision support system for push–pull supply chains with multiple demand fulfilment points, *Decision Support Systems,* 123, 113071

Gale, T., Rajamani, D. and Sriskandarajah, C. (2009). The Impact of RFID on Supply Chain Performance. Available from: https://www.researchgate.net/publication/247902358 [Accessed 22 May 2019].

Gautam, R., Singh, A., Karthik, K., Pandey, S., Scrimgeour, F. and Tiwari, M.K. (2017), Traceability using RFID and its Formulation for a kiwifruit Supply Chain, *Computers and Industrial Engineering,* 103, pp. 46–58

Giust, I., Cepolina, E. M., Cangialos, E., Aquaro, D. Caroti, G. and Piemonte, A., (2019), Mitigation of Human Error Consequences in General Cargo Handler Logistics: Impact of RFID Implementation, *Computers & Industrial Engineering*, 137, 106038

Haddud, A. (2011). A Study of the Relationship Between Radio Frequency Identification (RFID) Technology and Lean Manufacturing, Master's Theses and Doctoral Dissertations. Available from: http://commons.emich.edu/theses/329 [Accessed 3 September 2018].

Han, S., Zhao, L., Chen, K., Luo, Z-W and Mishra, D. (2017), Appointment scheduling and routing optimization of attended home delivery system with random customer behaviour, *European Journal of Operational Research,* 262, pp. 966 – 980

Heckmann, I., Comes, T. and Nickel, S. (2015), A critical review on supply chain risk – Definition, measure and modelling, *Omega,* 52 pp. 119–132

Hinkka, V. (2012). Challenges for Building RFID Tracking System Across the whole Supply Chain. *International Journal of RF Technologies: Research and Applications,* 3(1), pp. 201-218

Hu, J. and Haddud, A. (2017). Exploring the Impact of Globalisation and Technology on Supply Chain Management: A case of International E-Commerce Business, *International Journal of Operations Research and Information Systems*, 8(4), pp. 1 – 22

Huddiniah, E.R. and ER, M. (2019), Product Variety, Supply Chain Complexity and the Needs for Information Technology: A Framework Based on Literature Review, *Operations and Supply Chain Management*, 12(4), pp. 245 - 255

Hunt, D., Puglia, A. & Puglia, M. (2007) *RFID: A Guide to Radio Frequency Identification,* Canada: John Wiley & Son, Inc.

Ilie-Zudor, E., Kemeny, Z., van Blommestein, F., Monostori, L., and van der Meulen, A. (2011), A survey of applications and requirements of unique identification systems and RFID techniques, *Computers in Industry,* 62, pp. 227 – 252

Janssens, G.K. (2016). Recent Evolution in the Technology and Applications of Radio Frequency Identification Systems. Proceedings of the International Conference on Information Technologies. Available from: https://www.researchgate.net/publication/276100292 [Accessed 23 May 2019].

Jia, F., Gong, Y, and Brown, S. (2019) Multi-Tier Sustainable Supply Chain Management: The Role of Supply Chain Leadership, *International Journal of Production Economics,* 217, pp. 44 - 63

Ji, X., Feng. Q., Fan, T. and Lei, Q. (2012) RFID Technology and its Application in Internet of Things (IoT). Proceeding from the International Conference on Consumer Electronics Communication and Networks, Available from: https://doi.org/10.1109/CECNET.2012.6201508 [Accessed 03 June 2019].

Kamalapur, R. and Lyth, D. (2020) Impact of Stockout Compensation in E-Commerce Drop-Shipping Supply Chain, *Operations and Supply Chain Management*, 13(1), pp. 82 – 93

Kogan, K., Chernonog, T. and Avinadav, T. (2018), The Effect of Delivery Deviations on the Choice of a Supplier and the Supply-Chain Equilibrium, *Applied Mathematical Modelling,* 62, pp. 368–382

Kohler, C., Ehmke, J.F., and Campbell, A.M. (2020), Flexible time window management for attended home deliveries, *Omega*, 91, 102023

Kshetri, N. (2018), Blockchain's Roles In Meeting Key Supply Chain Management Objectives, *International Journal of Information Management,* 39, pp. 80–89

Lambert, D.M. (2014). *Supply Chain Management: Processes, Partnerships, Performances.* 4th ed. Ponte Vedra Beach, FL: Supply Chain Management Institute

Lee, C., Li, C. Cheng, C. and Lai, Y. (2019), A Novel Group Ownership Transfer Protocol for RFID Systems, *Ad Hoc Networks,* 91, 101873

Lee, I. and Lee, B.C. (2010), An Investment Evaluation of Supply Chain RFID Technologies: A Normative Modelling Approach. *International Journal of Production Economics,* 125(2), pp. 313-323

Leung, J., Cheung, W. and Chu, S. (2014), Aligning RFID Applications with Supply Chain Strategies, *Information and Management,* 51(2), pp. 260 - 269

Li, S., Godon, D. and Visich, J.K. (2010), An exploratory study on RFID Implementation in the Supply Chain Management. *Management Research Review,* 33(10), pp. 1005 - 1015.

Lin, L.C. (2009), An Integrated Framework for the Development of Radio Frequency Identification Technology in the Logistics and Supply Chain Management, *Computers and Industrial Engineering,* 57, pp. 832–842,

Lopez, Y. A., Fernandez, M.G., Narciandi, G.A., Arboleya, A.A., Andres, F. L-H., Cortes, S.G. and Cabanas, M.F. (2018), In Situ Antenna Diagnostics and Characterization System Based on RFID and Remotely Piloted Aircrafts, *Sensors and Actuators A,* 269, pp. 29–40

Lusk, J. (2017), 4 Benefits of RFID Technology for Business. Available from: http://info.odysseydcs.com/blog/4-benefits-of-rfid-echnology-for-business [Accessed 19 May 2019].

Mall, S. and Mishra, S. (2012). RFID and Supply Chain Management: A Brief Outline. Available from: https://www.researchgate.net/publication/255856999 [Accessed 30 May 2019].

Masum, A.K.M., Bhuiyani, F. and Azad, A.k. (2013). Impact of Radio Frequency Identification (RFID) Technology on Supply Chain Efficiency: An Extensive Study. *Global Journal of Researches in Engineering,* 13(4), pp. 9-16.

Nash, T.A. (2010). RFID Technology and Its Impact on the Supply Chain. Available from: http://commons.emich.edu/honors/243 [Accessed 25 May 2019].

Nath, B., Reynolds, F. and Want, R. (2006). RFID Technology and Applications. IEEE Pervasive Computing. 5(1), 22-24,

Nayak, R. (2019). Radio Frequency Identification (RFID) Technology and Application in Fashion and Textile Supply Chain. Boca Raton, FL: CRC Press/Taylor & Francis.

Nayak, R., Singh, A., Padhye, R. and Wang, L. (2015). RFID in Textile and Clothing Manufacturing: *Technology and Challenges. Fashion and Textiles,* 2(9), pp. 1-16

Ngai, E.W.T and Gunasekaran, A. (2009). RFID Adoption: Issues and challenges. International Journal of Enterprise Information Systems, 5(1), pp. 1 - 8.

Owunwanne, D. and Goel, R. (2010). Radio Frequency Identification (RFID) Technology: Gaining a Competitive Value through Cloud Computing. *International Journal of Management and Information Systems,* 14(5), pp. 157-164

Pal, K. (2019), Algorithmic Solution for RFID Tag Anti-Collision Problem in Supply Chain Management, *Procedia Computer Science,* 151, pp. 929 - 934,

Peppa, V.P. and Moschuris, S. (2013). RFID Technology in Supply Chain Management: A Review of the Literature and Prospective Adoption to the Greek Market. *Global Journal of Engineering Educations.* 15(1), pp. 61-68

Prentice, C., Wang, X., Maria, S. and Loureiro, C. (2019), The Influence of Brand Experience and Service Quality on Customer Engagement, *Journal of Retailing and Consumer Services,* 50, pp. 50–59,

Rao, K.V.S., Lam, S.F. and Nikitin, P. (2011). UHF RFID Tag for Metal Containers, Proceedings of Microwave Conference, Available Online from: https://ieeexplore.ieee.org/document/5728620?arnumber=5728620

Raweewan, M. and Ferrell, W.G. Jr (2018), Information sharing in supply chain collaboration, *Computers and Industrial Engineering,* 126, pp. 269–281

Reshma, R., Tejeswinee, K., Uva, R.J. and Balaji, A.S. (2015). Collision Avoidance in RFID Systems using Shadow Slot. *International Journal of Emerging Technology in Computer Science & Electronics,* 13 (1), pp. 388-392

Rizvi, S.S., Gebriel, E.M. and Riasat, A. (2008). RFID: A New Software Based Solution to avoid Interference. Advances in Computer and Information Science and Engineering, pp. 521-525, Available Online from: https://doi.org/10.1007/978-1-4020-8741-7-92

Roselli, L. (2014). *Green RFID Systems.* Cambridge, UK: Cambridge University Press.

Ruan, W., Sheng, Q.Z., Yao, L., Li, X., Falkner, N.J.G. and Yang, L. (2018), Device-Free Human Localization and Tracking with UHF Passive RFID Tags: A Data-Driven Approach, *Journal of Network and Computer Applications,* 104, pp. 78–96,

Sarac. A., Absi, N. and Dauzere-Peres, S. (2010). A literature review on the impact of RFID technologies on Supply Chain Management. *International Journal of Production Economics.* 128(1), pp. 77-95

Sari, K. (2010), Exploring the Impacts of Radio Frequency Identification (RFID) Technology on Supply Chain Performance, *European Journal of Operational Research,* 207, pp. 174–183,

Schallehn, S., Seuring, S., Strahle, J. and Freise, M. (2019), Customer Experience Creation for After-Use Products: A Products-Service Systems-Based Review, *Journal of Cleaner Production,* 210, pp. 929-944,

Shaikh, A., Al-Maymouri, R.K., Al-Hamed, L.H. and Dardas, A. (2014). The Role of RFID in Supply Chain Management Macro Processes, *International Journal of Innovation, Management and Technology,* 5(5), pp. 388 - 398,

Shin, S. and Eksioglu, B. (2014). Effects of RFID Technology on Profitability and Efficiency in Retail Supply Chain. Journal of Applied Business Research, 30(3), pp. 633-646,

Smart, A.U., Bunduchi, R. and Gerst, M. (2010). The Cost of Adoption of RFID Technologies in Supply Networks. *International Journal of Operations and Production Management,* 30(4), pp. 423 - 447

Tajima, M. (2007). Strategic Value of RFID in Supply Chain Management. Journal of Purchasing and Supply Chain Management, 13(4), 261-273

Ting, S.L., Tsang, A.H.C. & Tse, Y.K. (2013). A Framework for Implementation of RFID systems. *International Journal of Engineering Business Management,* Available from: http://emeraldinsight.com [Accessed 03 June 2019].

Tran, K.P., Nguyen, H.D., Thomassey S., (2019), Anomaly Detection Using Long Short Term Memory Networks and its Application in Supply Chain Management, *IFAC Papers Online,* 52(13), pp. 2408–2412

Tsai, W. and Tsang, L. (2012). A model of the adoption of Radio Frequency Identification technology: The Case of Logistics service firms. *Journal of Engineering and Technology Management,* 29(1), 131-151.

Tseng, M-L, Wu, K-J, Lim, M.K. and Wong, W-P. (2019), Data-Driven Sustainable Supply Chain Management Performance: A Hierarchical Structure Assessment under Uncertainties, *Journal of Cleaner Production,* 227, pp. 760-771,

Tu, Y-J., Zhou, W. and Piramuthu, S. (2018), A novel means to address RFID Tag/Item Separation in Supply Chains, Decision Support Systems, 115, 13–23

Upfold, C. and Lui, H. (2009), Radio Frequency Identification (RFID) Adoption in the South African Retail Sector: an Investigation of Perceptions Held by Members of the Retail Sector Regarding the Adoption constraints, *Electronic Journal of Information Systems Evaluation,* 13(1), 87-96

Usama, M. and Ramish, A. (2020), Towards a Sustainable Reverse Logistics Framework / Typologies Based on Radio Frequency Identification (RFID), Operations *and Supply Chain Management: An International Journal,* 13(3), pp. 222 – 232

Ustundag, A. and Tanyas, M. (2009), The impacts of Radio Frequency Identification (RFID) technology on supply chain costs, *Transportation Research Part E,* 45, pp. 29–38

Van de Meulen, R. (2018). How Your Supply Chain can improve the Customer Experience. Available online from: https://www.gartner.com/smartwithgartner/how-your-supply-chain-can-improve-the-customer-experience/ [Accessed 24 May 2019].

van der Togt, R., Bakker, P.J.M. and Jaspers, M.W.M. (2011), A framework for performance and data quality assessment of Radio Frequency Identification (RFID) systems in health care settings, *Journal of Biomedical Informatics,* 44, pp. 372–383

Visich, J.K., Li, S., Khumawala, B.M. and Reyes, P.M. (2009). Empirical Evidence of RFID Impacts on Supply Chain Performance. *International Journal of Operations and Production Management,* 29(12), pp. 1290-1315.

Waller, R. and Conaway, R. (2010). Framing and Counter framing the Issue of Corporate Social Responsibility: The Communication Strategies of Nikebiz.com. *Journal of Business Communication,* 48(1), 83-106.

Wamba, S.F., Anand, A. and Carter, L. (2013). RFID Applications, Issues, Methods and Theory: A Review of the AIS Basket of Top Journals. *Procedia Technology,* 9(1), pp. 421-430.

Wang, S., Li, Z., He, C. and Li, J. (2016). An Effective Scheduling-Based RFID Reader Collision Avoidance Model and Its Resource Allocation via Artificial Immune Network. *Mathematical Problems in Engineering,* p. 1-11, Available Online from: https://doi.org/10.1155/2016/7855154 [Accessed 03 June 2019].

Wantao Yu, W., Chavez, R., Jacobs, M.A. and Feng, M. (2018), Data-driven supply chain capabilities and performance: A resource-based view, *Transportation Research Part E,* 114, pp. 371–385

Wei, J., Zhao, J. and Hou, X. (2019), Bilateral information sharing in two supply chains with complementary products, *Applied Mathematical Modelling,* 72, pp. 28–49

Wu, Y. and Zhu, L. (2017), Joint quality and pricing decisions for service online group-buying Strategy, *Electronic Commerce Research and Applications*, 25, pp. 1–15

Yang, Z., Zhang, P. and Chen, L. (2016), RFID-enabled indoor positioning method for a real-time manufacturing execution system using OS-ELM, *Neurocomputing*, 174, pp. 121–133

Yusof, M.K. and Saman, Y. (2016). The Adoption and Implementation of RFID: A Literature Survey. *Library and Information Science Research e-Journal*, 26(1), pp. 31-52

Zhang, L-H., Li, T. and Fan, T-J. (2018), Radio-frequency identification (RFID) adoption with inventory misplacement under retail competition, *European Journal of Operational Research*, 270, pp. 1028–1043

Zhang, X., Ming, X., Liu, Z., Qu, Z. and Yin, D. (2019), A framework and implementation of Customer Platform-connection manufactory to service (CPMS) model in product service system, *Journal of Cleaner Production*, 230, pp. 798 - 819

Ms Palesa Kgobe is a Master's degree candidate in the Department of Quality and Operations Management, University of Johannesburg (UJ). She obtained a National Diploma in Biotechnology from the Vaal University of Technology (VUT) and Bachelor of Technology from the University of Johannesburg. In addition to that, she worked as a Quality Controller for certain brewing and beverage companies before pursuing her master's degree full-time. Her research interests include Warehouse Operations, Material handling and Quality control, Optimisation of warehouse processes, Lean warehousing, Emerging technologies in Supply Chain Management, and Quality Management Systems.

Paul A. Ozor has a bachelor's degree (B.Eng) in Mechanical/Production Engineering. He worked as project manager with some engineering companies before proceeding to Department of Mechanical Engineering, University of Nigeria Nsukka (UNN), where he specialized in Industrial Engineering and Management. He obtained both Master's and PhD degrees from UNN. Dr Ozor is a winner of the prestigious TWAS-DST-NRF fellowship to University of Johannesburg, South Africa, and had been awarded the Association of Common Wealth Universities' (ACU) early career scholarship. His research interests include Industrial Operations modelling/management, Quality management, Systems Analysis and Reliability Engineering, with special emphasis on Asset Management. Dr Ozor has over fifty peer-reviewed publications in local/International Journals and conferences. He has visited many countries in Africa, Asia, North America and Europe on research grounds.