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RFID technology usage effect on enhancing warehouse internal processes in the 3pls providers: An empirical investigation in Jordanian manufacturing firms

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In the last two decades due to fast enhancing technology tools such as Radio frequency identification (RFID), which plays a crucial role in enhancing the ability of many firms to obtain a wide array of information about the site and features of any entity that can be physically tagged and wirelessly scanned within certain technical limitations. Furthermore, RFID technology can be adopted and implemented in a range of diverse functions, duties, and business-to-business systems (B2B) along the value chain, including services, intra-business logistics activities, as well as marketing and after-sales service applications. In total, 26 semi-structured interviews were involved in this study; several interviews were applied with senior, production, operations, facilitation, distribution, logistics, and warehouses managers, senior 3PLs provider managers, and supervisors and warehouses men from Alkasih and five 3PLs providers in Jordan country. Our forecast results for the third-party logistic providers' sample have shown an enormous growth that would reach 38.5% by 2030. Therefore, we have proposed RFID as a business process reengineering technique to mitigate the coming growth instead of expansion that would cost a huge amount of money due to land high costs. Moreover, we have noticed through our visits that the space utilization and warehouse capacity are very high and most of the warehouses are seeking expansion or employing additional operators to handle the current growth.

1. Introduction

In SCM literature, a warehouse is a crucial element for linking several chain partners within each SCM network. With warehousing having been referred to as "transportation at zero mile per hour" (Murphy & Knemeyer, 2015), in the contract most of the warehouse activities like order picking, sorting, packaging, and truck unloading and loading operations are some of the most labor-intensive and capital-intensive operations in the logistic network (Seyis & Mert Sönmez, 2022). The performance of a firm and its supply chain (SC) operations does not affect only the levels of productivity and operational costs of warehouses, but also includes the entire SC. Therefore, misuse and loss of space and not using them optimally in warehouses are usually costly for firms, and this includes manual errors in the process of locating products in warehouses and identifying wrong products during the receiving and sending stages. All of this certainly negatively affects productivity and profitability in general, which may harm the firm's reputation and its SC as well. Therefore, it is necessary to focus on the importance of improving and enhancing the level of productivity through various operations and logistical activities and reducing the operational costs of warehouses in the SC network of firms. From the perspective of warehousing and shipping to managing customer service and the security of their products, many firms, their SCs, and networks, are looking to continuously improve their operations and various logistical activities, so the process of adopting a warehouse management system (WMS) is one of the main and important keys in SCs. Therefore, automating a group of logistical operations and linking them to each other through special programs such as Radio frequency identification (RFID) technology can increase

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production efficiency, reduce human errors, and thus have a positive and important impact on logistical activities in general and business. (Moon et al., 2018; Mejjaouli & Babiceanu, 2015). However, it is difficult to update daily operations of inventory level, locations of forklifts and stock keeping units (SKUs) in real-time by using the barcode-based or manual-based WMSs. Li et al. (2011) argue that "Hence, incorrect information is inevitable because human error is account for around 80% of incorrect information, the efficiency of the warehouse is unsatisfied, as a result, these practical problems and hot issue are increasingly becoming the bottleneck of the business and reduce the advantage of economies of scale". RFID tool is an emerging technology that is increasingly being used in different businesses and industries particularly in logistics and SCM as well (Li et al., 2017). RFID technology is designed to replace conventional barcodes in numerous ways. It can make continuous tracking of an item/product/batch in wireless and allows its reader to stimulate/hold a transponder on a radio frequency tag attached to that item/batch, or embedded in, then allowing the reader to remotely read and/or write the data that is included in the RFID tag. Therefore, both properties of RFID for identification and tracking may enhance the firm's capability to acquire a real-time based information system about the location and main features of the tag that already has fixed on item/product/batch/people and equipment. Thus, real-time information can be obtained without the RFID technology tool (Qi *et al.*, 2018; Garcia *et al.*, 2007), but using this tool can facilitate gaining it. Therefore, in warehouses that store different inventories inside, the main warehouse processes and operations are working to receive the targeted stock keeping units (SKUs) from several suppliers from different countries. Further, it keeps the SKUs at minimum levels with storage in different distributed locations, and receives different orders from several customers, retrieve SKUs from storage locations, assemble them to be ready for freight and ship the completed orders to customers. Storing and picking/retrieving are the most expensive logistical activities because they tend to be either very labor and/or capital intensive (Xue et al., 2018).

According to our forecast for several 3PL's providers and many interviews with operations managers across the Jordanian service sector. The third-party provider's service sector is having a steady and our forecast shows a 34% growth by 2030. Moreover, the foreign investments and globalization has led to an enormous increase in competition in the service sector and many other sectors. As a result, the rule of competition has changed and it is no longer a company vs a company; it is about managing the whole SC and getting it to work as efficiently and effectively as possible. Warehouses play a vital role in the SC, as it is the major link between the upstream and the downstream. Therefore, warehouse management systems are one of the primary issues these days in order to optimize and manage the operations. However, after our visit to many warehouses across Jordan, we found that the WMSs used are very weak & unreliable because they rely on the warehouse staff to gather the operational data manually or through a bar-code system. In addition, human errors can play a vital stake in this issue where it counts approximately 80% of the incorrect information & mistakes that happen in the warehouse. As a result, this old-fashioned practice is like a bottleneck for the warehouse operational process and in order to compete and match the new global competition, some measures and actions have to be taken.

RFID is one of the most promising technologies that can be adopted to increase performance by increasing efficiency and effectiveness.

1.1 Research Question

The main question for this study focuses on: *"What are the benefits obtained when facilitating the 3PL's warehouse operations using RFID technology?"* This question presents RFID as an enabling technology in the service sector. Therefore, the main benefits who will get from using RFID technology will focus on the main boundaries within the warehouses' context. Its main characteristics that drive its enormous advantages are wireless readability, reusability, small size and comparatively low cost. In this study, we are going to address the merits and characteristics of the RFID and we are going to address the impact of the RFID technology on enhancing warehouse internal processes in the 3PL providers in Jordan.

2. Literature Review

There is near consensus in many studies in the SCM literature that RFID technology provides many advantages and improves the capabilities of SCs in various areas such as unique product identification, smart communications and real-time based information system (Mahdaly & Adeinat, 2022; Hardgrave et al., 2013; Sarac et al., 2010). These capabilities affect all logistical aspects, activities, and operations in SCs such as transportation logistics management, packaging and material handling as well as warehouse management, production scheduling and orders Haddara and Staaby, 2018; Poon *et al.*, 2009).

The aim of the research is to study the benefits that can be obtained if RFID is used in a 3PL's warehouses. We will list the emergence of this technology by briefly speaking about the Kanban and electronic Kanban techniques.

2.1 Kanban technique literature

A Kanban (Kan or 'card' and ban or 'signal') is a manufacturing control technique used in just in time distribution systems; it is the logistics management mode within firms, which was developed by Toyota Company since 1955. Kanban cards have traditionally operated as a manual signal and indicate the essential information for the supply like item information, part name, description and quantity (Lim *et al.*, 2013). They allow the information to be available and accessible to everyone by providing the view for these cards to all involved people, it is therefore possible to mitigate and predict delays, and it works on smooth and efficient flow of goods all the time supply chain entities. The Kanban system may be successful when the demand is linear and with realistic lead times.

2.2 Electronic Kanban (barcoded Kanban card) literature

Low accuracy caused by manual errors, lack of writing off the cards, and the possibility of losing or duplicating the card, it will lead to mismanaged inventory, lack of reliable information and in inventory being carried as safety stock, all process with a manual intervention results a serious problem to the stock management (Mahdaly & Adeinat, 2022). Successive improvements have been made in many functions and activities of SC, and the whole SC entities are consistently looking for information technology (IT) that can improve performance and keep them competitive. Hence the need to create a new consumption replenishment system, integrated with software like enterprise resource planning (ERP), by increased team efficiency through improved communication and collaboration, eliminates lost cards, reduces manual card handling and order-entry activities, speeds analysis of supplier performance, and enables real-time visibility of demand signals (Qin *et al.*, 2017; Proctor-Parker and Stopforth, 2021).

2.3 RFID literature

RFID (radio-frequency identification) is a way of automating processes that used to be carried out manually. The technology provides contactless identification and monitoring. The RFID technology includes a tag affixed to the product/object or to the order, through which the order is identified and tracked via radio waves. These tags carry 2500 bytes or more of data/information. Note that, the RFID technology consists of three main parts: transmitter, receiver, and a scanning antenna; as well as a decoder, a coding unit for data reinterpretation, and a transponder (RFID tag) device preset with information, where the signals and information are sent through the scanning antenna by radio frequencies through effective means of communication with the RFID tags. In addition, when the RFID tags pass through the antenna scanning frequency range, it detects the activation signal and through it the signals, data and information are transmitted in the reservations to be then captured by the aerial scanning.

3. Research Methodology

3.1 Research purpose and direction

This research would forecast the future trends, discuss the RFID benefits, and present a set of questions that are related to how RFID technology would be improved, adopted, and implemented by the main 3PL's providers, and impacts individuals, business processes, and markets.

3.2 Qualitative Research Study

The qualitative methodology adopted for this study is one of the best ways to describe a specific case, phenomenon, or situation (AL-Shboul, 2019). According to Voss et al. (2002), this methodology tries to deeply understand several real-world phenomena in SCM in general, warehouse logistics in particular. This kind of methodology can be applied in several types of research, which can produce outcomes not arrived at by statistical ways or other methods of qualifications (Strauss and Corbin, 1998). Therefore, qualitative research focuses on the study of the research cases, the different practices in organizational performance, social behaviors, living experiences, and different phenomena, in addition to the different feelings and emotions among nations. Ruyter and Scholl (2008) emphasized that this is in addition that this type of methodology provides an in-depth and highly valuable understanding of a particular event or practice, and therefore of its qualities and characteristics also to reach tangible results at the same time and adds facts to the practical life full of different realistic ideas. Takashima and Kim (2016) argue that to increase the reliability of the results and analysis, this research contains a unit of analysis only for practitioners and decision-makers who are able to make proper decisions to improve all internal processes within Jordanian firms' warehouses and their 3PL providers at medium and top-level positions that were related to logistical warehouses activity as targeted respondents. Fig. 1 illustrates the process of adoption of RFID technology as an effective technique to enhance warehouse internal processes in the 3PLs providers in Jordanian manufacturing firms using an inductive research approach.

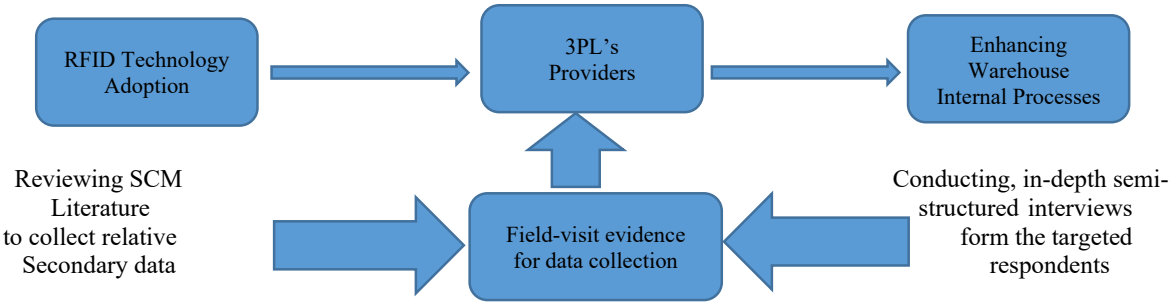

Fig. 1. Research study approach
Source: Stank *et al.* (2017) with some modifications by Author(s).

3.3 Data gathering

The primary data were gathered over three months, in the period between March and April 2022. Alkasih Food Company as a manufacturing company and its warehouses, and five 3PL providers (i.e., Aramex, Abu Jabber, Mooneh for logistics and trading, Agility, and Darab) were involved in this study from Jordan. The participating company was similar to the companies that engaged in the manufacturing sector and logistical distributing activity. This manufacturing company and its depots had above 330 employees and operated their own in-house food-manufacturing activities.

3.3.1 Semi-structured interviews and site visits

The formulated questions in the survey asked to the targeted respondents through face-to-face semi-structured interviews, which are focused on the following warehousing aspects: from your point of view to what extent is RFID technology applied in supply chains? In your opinion, what are the logistics functions and activities in which RFID technology is used in supply chains? What are the most important benefits that are obtained in the warehouse when RFID technology is used? A detailed elucidation of the receiving & put-away processes; methodology, durations, employees needed & frequency? What is the type of the racking system used and how does it incorporate the type, frequency and number of SKUs received? How much is the yearly throughput? What is the frequent employee utilization, pallet per hr.? Finally, what is the frequency of human errors and how much does it approximately cost? The primary aspects that included in the interviews for this study came from SCM and warehousing management and logistical activities literature. In total, 26 semi-structured interviews were involved in this research; multiple interviews were applied with senior, production, operations, facilitation, distribution, logistics and warehouses managers, senior 3PLs provider managers, and supervisors and warehouses men from Alkasih and five 3PLs providers in Jordan country to get high-level of data reliability (Eisenhardt & Graebner, 2007). Table 1 illustrates specific details about all these issues. Site visits were undertaken at the warehouses and staff communicated to understand the processes clearly from product arrival until dispatching. Thirteen site visits were performed to examine the place of storing quantities of pallets/products/cases/items/objects that produced by Alkasih Food Production Company and its warehouses with cooperation with five 3PLs providers. Accordingly, we proposed two scenarios based on the 3PL practices.

In order to create a clear picture of the operations within the warehouse and to understand RFID technology where RFID technology is not used by any of the third-party logistics providers in Jordan yet. We sought to find a warehouse that possessed this technology and to help us analyze its impact on internal processes, and the extent of improvement that occurred after implementation. This led us to the study of Kasih Food Production Company, which is one of the few warehouses that benefit from this technology. Ketokivi and Choi (2014) emphasized in their study that it is crucial to include all necessary and obtained information to be summarized within one table to increase reliability during the study data collection process. Table 1 shows a clear picture and road map for the implemented procedure for the evidence of data-collection from Alkasih Food Production Company and the five 3PLs providers that participated in this study from Jordan.

Table 1
Summary of conducted Semi-structured Interviews

Company/3PLs Provider	Interviews (Interviewee position, no. of interviews, and interviews length in min., no. of site visit)	Proof of data gathering (Location, date, no. of hours spent)
Alkasih Food Production Company	(Warehouse manager, 3, 50, 1) (Production manager, 2, 40, 1)	(Jordan, March 2022, 1h)
Aramex	(Senior 3PLs provider manager, 1, 25, 1) distribution, 2, 45, 1)	(Jordan, April 2022, 1.5h)
Mooneh	(Senior, 3PLs provider 2, 40, 1) Operations manager, 1, 40, 1)	(Jordan, April 2022, 2h)
Abu Jabber	(Logistics and warehouses manager, 3, 60, 1) (Operations manager, 2, 50, 1)	(Egypt, April 2022, 2h)
Agility	(Warehouses man, 2, 35, 1) (Distribution manager, 2, 40, 1)	(Jordan, March 2022, 2h)
Darab	(Facilitation manager, 1, 40, 1) (Senior manager, 3, 30, 1) Distribution manager, 2, 40, 1)	(Jordan, March 2022, 1.5h)

3.3.2 KASIH food operational context

ALKASIH Food Production Company is one of the leading Jordanian manufacturers of canned and boxed Mediterranean food since1926. ALKASIH produces finished products for sale and distribution to wholesalers and retailers, and manages production facilities and distribution centers to support these operations.

Information of the SKUs that were stored and retrieved was collected and presented in Table.2. A warehouse layout as illustrated in Fig. 2 and was configured so that we could imagine the operations that were taking place within it.

Table 2
Number of SKUs for finished products.

Items	Number of SKUs for finished product			
	Cans	Weight	Number of pcs per carton	Number of carton per pallet
1	Hummus Tahini-hot chili	400 gm	24	80
2	Hummus Tahini-roasted garlic	400 gm	24	80
3	Hummus chick peas	400 gm	24	80
4	large beans	400 gm	24	80
5	small beans	400 gm	24	80
6	beans with hot sauce	400 gm	24	80
7	Green peas	400 gm	24	80
8	White beans	400 gm	24	80
	Tetra Pack	Weight per pcs	Number of pcs per carton	Number of carton per pallet
9	Hummus Tahini	50 gm	48	130
10		70 gm	48	130
11		135 gm	48	130
12		1000 gm	24	80
13	Liquid Jameed	500 gm	48	130
14		1000 gm	24	80
15		2000 gm	24	80
16	lentil soup	135 gm	48	130
17		500 gm	48	130

3.3.3 Operations complexity

Table 1 indicates that the number of SKUs produced during the month are seventeen SKUs, based on the agent's demands at the level of the local market, government institutions and foreign exports. It is also worth mentioning that the expiry date is very important when we are talking about the food production sector, first in first out (FIFO) this is as deceptively easy as it appears. Using this approach means that the first lot of products that come into the warehouse should be the first one that should go out and sent directly to customers. FIFO is a great strategy because the products have a shelf life. With this technique, you try to move whatever comes into your warehouse first. If it stays on the shelves while you sell newer items/products, you probably will lose money as it expires. Moreover, the expiration date for the products which exported outside Jordan is not consolidated as they vary according to the customer's requests, where one of the customers' requests that his products to be valid for one year and the other requires two years and so on. Each SKUs mentioned in Table 1 have an incubation period that starts from the moment they are stored on the shelves until the date determined by the quality team, during this period the products are not allowed to leave the warehouse. Samples are taken to ensure that the quality is met until the end of this period.

Fig. 2. Top view of finished products layout warehouse

After mentioning some of the activities occurring within the warehouse, the questions here are what scenarios are likely to occur without RFID? What does the operations complexity mean?

3.3.4 Scenarios and operations complexity

The dry store warehouse Fig. 2 consists of 6200 pallet position, with high-density block of racks; storage facility with an area of 2400 square meters only, served by the pallet shuttle offers high-capacity storage that work within the channels with only two transfer aisles north and south. With an average of 50,000 finished products distributed annually to the customers, in addition to the form of storage facility, from here the complexity begins. Because of the multiple conditions that the workers and the warehouse manager abide by to meet the daily demand, some of them can be met at the expense of the labor cost, time and others cannot be fulfilled since human error is uncontrollable. The assumptions here suppose that there is an order for tetra pack pallets. Three finished products Hummus Tahini with 70 gm, 135 gm and 1000 gm, allocated at Xi locations in Fig. 2, to be exported to Iraq customers, with three years expiry date. Also, suppose that there is another order for cans pallets; two finished products white beans with 400 gm, and three finished products liquid Jameed with 500 gm and 1000 gm, allocated at Yi locations in Fig. 2, with two years expiry date to be distributed for the local market. What about FIFO strategy that should be applied in food production? How can you know along all the 6200 blocks? What we store firstly should be the first

lot of products that comes into our warehouse should be the first one that should go out? As we mentioned earlier in the operation complexity section if the finished products sit on racks while you store newer products, the company will lose money as it expires. The laboratory technician may need to take a sample of the tomato product during the incubation period in location X to ensure that the specifications conform.

3.3.5 ALKASIH Results and Discussions

For all of the above discussion, we can imagine the large number of operations required by warehouse operators for retrieving products and laboratory technicians for checking samples, which requires a large number of operators and technicians, time and supervision. There would be many human errors that cannot be controlled. For example, we cannot make sure that the operators loaded the right product; may be large or small beans, with the right weight, quantity, validity date required to the right customer. Hence, the importance of adding RFID enhanced real-time information. Table 3 shows the percentage improvements that were made after the implementation of the RFID system in ALKASIH warehouse.

Table 3
Improvements percentage by RFID implementation

Benefits	Improvements Percentage
Better inventory accuracy	Up to 99.9%
Human error	Up to 99.9%
Inventory holding cost	Up to 20-30%
Reduced receiving time	Up to 90%
Increase picking accuracy	Up to 90%

3.3.6 Third Party Logistics (3PLs) Provider Context

3PLs is used in logistics and supply-chain management to outsource part or all a business distribution and fulfilment services. We conducted our research for the top five third party logistics providers across Jordanian market, “Aramex, Abu Jabber, Mooneh for logistics and trading, Agility & Darb”. These firms smoothly facilitate the flow of items/products/materials from suppliers' suppliers until the manufacture and movement of finished products from manufacturers to distributors and retailers. Many services they can provide as logistical transportation, warehousing management, inventory control, cross-docking, inventory management, packaging and freight forwarding as well. With mutually beneficial and risk sharing relationships with long-term commitment (1-3 Years).

3.3.6.1 Forecasting

In order for any firm to keep going under this competitive environment, an appropriate forecast method should be depended on, to predict the demand, and accordingly plan the supply that matches the forecasted demand. This forecast is considered meaningful if it will reduce uncertainty of events in the future and be accurate as much as possible. We made our calculations on the provided actual yearly outbound logistics for various 3PL’s and we measured the forecasted demand growth for 2030 using linear regression method. Our forecast population was a compilation of the biggest 3PL’s across Jordan such as Aramex, Abu Jabber, Mooneh for logistics and trading, Agility & Darb. The details go as illustrated in Tables 4,5, 6,7, and 8, and Figs. 3, 4, 5, 6, and 7.

- *Aramex Company*

Table 4
Forecasting Table of Aramex Company

Year	t	y	t^2	ty	F	A-F
2016	1	200,402.00	1	200,402.00	153555.095	46846.90476
2017	2	215,516.00	4	431,032.00	214684.124	831.8761905
2018	3	235,253.00	9	705,759.00	275813.152	40560.15238
2019	4	276,309.00	16	1,105,236.00	336942.181	60633.18095
2020	5	403,456.00	25	2,017,280.00	398071.21	5384.790476
2021	6	507,330.00	36	3,043,980.00	459200.238	48129.7619
2022	7		49	0.00	520329.267	
2023	8		64	0.00	581458.295	
2024	9		81	0.00	642587.324	
2025	10		100	0.00	703716.352	
2026	11		121	0.00	764845.381	
2027	12		144	0.00	825974.41	
2028	13		155	0.00	92728.87	
2029	14		178	0.00	105651.41	
2030	15		192	0.00	123765.33	
SUM	19	1,838,266.00	91	7,503,689.00		33731.1111
	b=	61129.02857	a=	92426.06667		
Linear Trend		a		b	Fy	
		92426.06667		61129.02857	61129t+92426	
			MAD	2,810.93		

Growth % By 2030 44.40503%

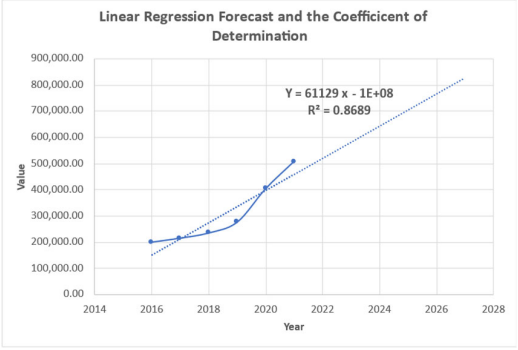

Fig. 3. Coefficient of determination (R^2)-Aramex Company

- R squared is a measure of the percentage of variability in the values of Y data that is affected by the independent variables. Moreover, as William Stevenson explains in his book "Operations Managements, 12th edition ", if the coefficient of determination (R^2) is greater than 0.7, then the linear regression method is a valid method to be used for forecasting. In our case, the ratio of determination is 0.8689, which is sufficient.
- The forecaster shows an exponential growth on the outbound logistics which is forecasted to increase in 2030 by 44.4% more than 2021.

➢ *Abu Jabber Company*

Table 5
Forecasting Table of Abu Jabber Company

Year	t	y	t2	ty	F	A-F
2016	1	72,321.00	1	72,321.00	63543.4286	8777.571429
2017	2	71,176.00	4	142,352.00	75110.6571	3934.657143
2018	3	84,620.00	9	253,860.00	86677.8857	2057.885714
2019	4	84,511.00	16	338,044.00	98245.1143	13734.11429
2020	5	115,305.00	25	576,525.00	109812.343	5492.657143
2021	6	126,836.00	36	761,016.00	121379.571	5456.428571
2022	7		49	0.00	132946.8	
2023	8		64	0.00	144514.029	
2024	9		81	0.00	156081.257	
2025	10		100	0.00	167648.486	
2026	11		121	0.00	179215.714	
2027	12		144	0.00	190782.943	
2028	13		152	0.00	2010763.87	
2029	14		161	0.00	243765.98	
2030	15		167	0.00	256761.63	
SUM	21	554,769.00	91	2,144,118.00		6575.55238
	b=	11567.22857				
	a=	51976.2				
Linear Trend		a		b	Fy	
		51976		11567	11567+51976	

MAD	547.96
Growth % by 2030	36.37818

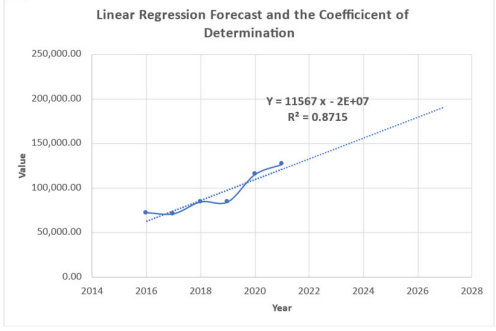

Fig. 4. Coefficient of determination (R^2)-Abu Jabber

- The coefficient of determination (R^2) is greater than 0.7, then the linear regression method is a valid method to be used for forecasting. In our case, the ratio of determination is 0.8715, which is sufficient.
- The forecaster shows an exponential growth on the outbound logistics which is forecasted to increase in 2030 by 36.4% more than 2021.

➢ *Mooneh Company*

Table 6
Forecasting Table of Mooneh Company

Year	t	y	t2	ty	F	A-F
2016	1	20,411.00	1	20,411.00	16946.1905	3464.809524
2017	2	23,547.00	4	47,094.00	22470.6476	1076.352381
2018	3	23,865.00	9	71,595.00	27995.1048	4130.104762
2019	4	25,671.00	16	102,684.00	33519.5619	7848.561905
2020	5	45,502.00	25	227,510.00	39044.019	6457.980952
2021	6	45,548.00	36	273,288.00	44568.4762	979.5238095
2022	7		49	0.00	50092.9333	
2023	8		64	0.00	55617.3905	
2024	9		81	0.00	61141.8476	
2025	10		100	0.00	66666.3048	
2026	11		121	0.00	72190.7619	
2027	12		144	0.00	77715.219	
2028	13		149	0.00	89551.651	
2029	14		154	0.00	93762.852	
2030	15		163	0.00	10176.435	
SUM	21	184,544.00	91	742,582.00		3992.88889
	b=	5524.457143				
	a=					
Linear Trend	a		b	Fy		
	11421		5524	5524t+11421		
MAD	332.74					
Growth by 2030	42.65154659					

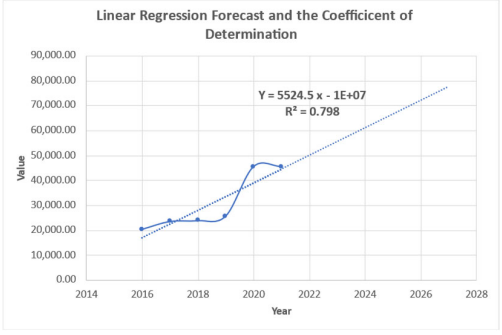

Fig. 5. Coefficient of determination (R^2)-Mooneh

- The coefficient of determination (R^2) is greater than 0.7, then the linear regression method is a valid method to be used for forecasting. In our case, the ratio of determination is 0.7988, which is sufficient.
- The forecaster shows an exponential growth on the outbound logistics which is forecasted to increase in 2030 by 42.6% more than 2021.

➢ *Agility*

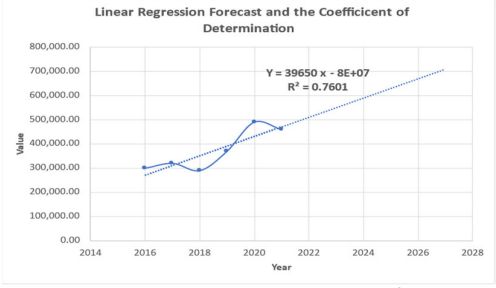

Fig. 6. Coefficient of determination (R^2)-Agility

Table 7
Forecasting Table of Agility Company

Year	t	y	t2	ty	F	A-F
2016	1	300,649.00	1	300,649.00	273104.429	27544.57143
2017	2	320,742.00	4	641,484.00	312754.657	7987.342857
2018	3	290,658.00	9	871,974.00	352404.886	61746.88571
2019	4	370,428.00	16	1,481,712.00	392055.114	21627.11429
2020	5	490,528.00	25	2,452,640.00	431705.343	58822.65714
2021	6	460,375.00	36	2,762,250.00	471355.571	10980.57143
2022	7		49	0.00	511005.8	
2023	8		64	0.00	550656.029	
2024	9		81	0.00	590306.257	
2025	10		100	0.00	629956.486	
2026	11		121	0.00	669606.714	
2027	12		144	0.00	709256.943	
2028	13		157	0.00	78876.511	
2029	14		169	0.00	84871.677	
2030	15		187	0.00	94878.881	
SUM	21	2,233,380.00	91	8,510,709.00		31451.5238
	b=	39650.22857				
	a=	233454.2				
Linear Trend	a			b	Fy	
	233454			39650	39650t+233454	
			MAD	2,620.96		

Growth%
by 2030 33.54233946

- The coefficient of determination (R^2) is greater than 0.7, then the linear regression method is a valid method to be used for forecasting. In our case, the ratio of determination is 0.7601, which is sufficient.
- The forecaster shows an exponential growth on the outbound logistics which is forecasted to increase in 2030 by 33.5% more than 2021.

➢ *Darb Company for Logistics and Trading*

Table 8
Forecasting Table of Darb for Logistics and trading Company

Year	**t**	**y**	**t^2**	**ty**	**F**	**A-F**
2016	1	85,237.00	1	85,237.00	88637.8571	3400.857143
2017	2	103,652.00	4	207,304.00	102403.514	1248.485714
2018	3	100,928.00	9	302,784.00	116169.171	15241.17143
2019	4	150,771.00	16	603,084.00	129934.829	20836.17143
2020	5	159,762.00	25	798,810.00	143700.486	16061.51429
2021	6	137,962.00	36	827,772.00	157466.143	19504.14286
2022	7		49	0.00	171231.8	
2023	8		64	0.00	184997.457	
2024	9		81	0.00	198763.114	
2025	10		100	0.00	212528.771	
2026	11		121	0.00	226294.429	
2027	12		144	0.00	240060.086	
2028			163	0.00	297542.876	
2029			176	0.00	379857.553	
2030			184	0.00	495663.215	
SUM	21	738,312.00	91	2,824,991.00		**12715.3905**

b= 13765.65714

a= 74872.2

Linear Trend	a	b	Fy
	74872	**13765**	**13765t+74872**
		MAD	**1,059.62**
		Growth% by 2030	34.40552919%

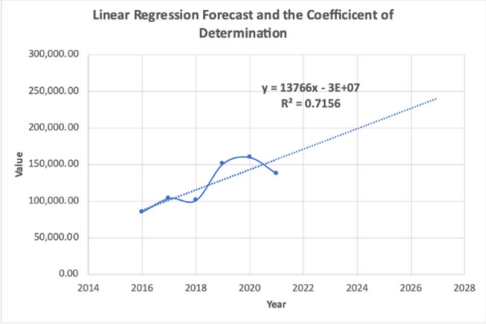

Fig. 7. Coefficient of determination (R^2) - Darb for Logistics and trading.

- The coefficient of determination (R^2) is greater than 0.7, then the linear regression method is a valid method to be used for forecasting. In our case, the ratio of determination is 0.7156, which is sufficient.
- The forecaster shows an exponential growth on the outbound logistics which is forecasted to increase in 2030 by 34.4% more than 2021.

4. Results

Table 9
Summary of Growth rates for all 3PL Providers

3PL Providers	Growth % by 2030
ARAMEX	44
MOONEH	42
AGILITY	33
DARB	34
ABU JABBER	36

Table 9 shows the growth rates for all 3PL providers of ALKASIH Company until 2030.

4.1 Forecasting conclusion

As per our conclusion from the forecast, it is estimated that the average outbound logistics in the 3PL's in Jordan will grow by 38.25% in 2030. Therefore, this enormous growth would require the 3PL sector to take some measures to keep more competitive in the new business challenges. New measures have to be taken in order to increase the efficiency of picking and all the warehouse internal functions to adapt with the coming growth. From here rise our proposal to install RFID systems that will help the organization survive and compete in the coming competitive environment.

4.2 Practices and internal processes

The average warehouse of our study consists of eleven pickers, one data entry and one supervisor. After the shipment arrives, the following activities are carried out and divided into two scenarios:

The first case scenario was concluded based on interviews with the warehouse managers we met. After receiving the loaded pallets, the boxes are opened to scan each piece and each worker can scan up to 2500 pieces per day. After the scanning process, the put away takes place and then the location must be entered on the system. Average shipments that contain 10,000 pieces would require four full time workers for a whole day to scan and put away. Moreover, the supervisor of Aramex stated in an interview that the human errors in scanning costs approximately 10% of the total cost of the shipment. In addition to that, in the picking process, each worker can pick up to 340 pieces per day on average and the human errors accounts for 10% of the total shipment cost as well. If we talk in the language of money, if we assume that, the cost of one shipment of 10,000 items is 30,000 JD and the worker salary is 500 JD. The shipment scanning cost would be 100 JD per shipment and the human error counts four the loss of 10% of the total cost of the shipment which is about 3000 JD per shipment. Therefore, the total money lost on every shipment is approximately 3100 JOD for the put away process. The maximum capacity for the warehouse is to receive not more than three shipments with 10,000 pieces per day if the entire worker is on full time bases for receiving. However, all the 3PL warehouses we have though are almost under full capacity and their utilization is very high. Moreover, in the 3PL's it is generally common between the client and the 3PL's provider such as "Aramex, mooneh, etc. "to have a contract that the 3PL's provider can take any number of shipments from the clients and the 3PL can't reject any shipment. From this case, we noticed some pallets on the flour in Aramex & Abu Jabber warehouses because of the huge amount of pallets coming in and the continuous growth of suppliers and the warehouse's huge space utilization.

The second case scenario does not have a barcode system at all where the traditional paper methodology is used, such as the one used on DARB and MOONEH. In addition, based on the interview results we found out that it requires double the time

of the barcode system and the human error rises up to 15%. Moreover, in this case, more operators would be needed for the documentation submission of proposals and data entry.

4.3 Proposed solution

The number of stocks keeping units (SKUs) stored in 3PL's warehouses is constantly increasing based on our forecasting, so we proposed a shuttle-tracking system, which can utilize as much space as possible in cold store warehouses.

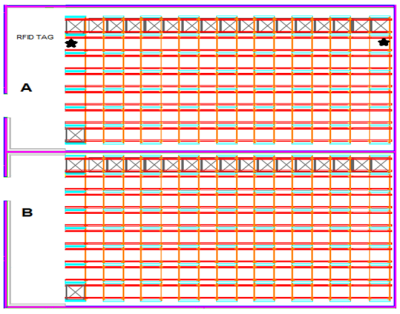

Fig. 8. Proposed Shuttle System Warehouse Layout

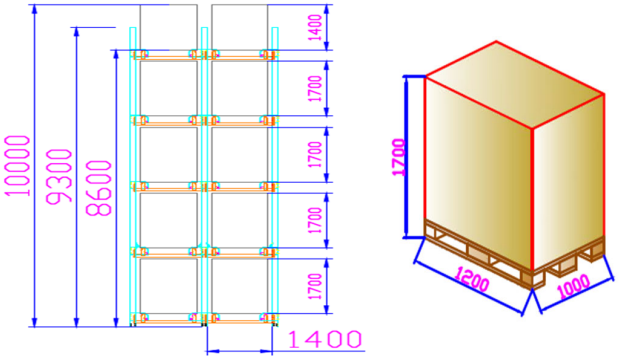

Fig. 9. Proposed Shuttle System Warehouse Layout

Fig. 8 indicates the top view of a high-density cold store shuttle system with high space utilization, and with last in first out (LIFO) stock rotation. Fig. 9. Indicates the average warehouse height and product dimensions received by the third party logistics provider. The two layouts for two contractual customers A and B, and according to the average warehouse height and load dimensions, each block will be with 680 pallet position, with storage facility with an area of 235 square meters only for each one. This study included using a methodology that has six stages of warehouse activities analysis: For the receiving and inbound zone transfer process, and instead of using traditional manual inspection or even scanning the barcode for each product entering the warehouse. Which requires many workers and it takes a longer time to complete this process, there is also the possibility of human error where every pallet needs to be inspected manually and then recorded onto paperwork and signed off. The proposed solution receiving area was to use a reusable RFID tag that has the capability of huge quantities of data such as product information, shipping histories and expiry dates; all these information can be programmed and stored within the tag. Moreover, for inbound zone transfer process by using RFID gantries to be installed at handover zone boundaries so when the pallet passes through the boundary it is automatically detected and the zone transfer is electronically processed without the need for the driver to slow down. When a pallet enters their wrong boundary an alert is triggered, for example if a product comes from customer A and enters the customer's area B, the alarm will indicate that the product has been entered into the wrong area, this alert will reach warehouse supervisors via WMS.

For the put away process, and instead of using a put away code, excel sheet or use a handheld terminal to scan the pallet barcode. The pallet is then placed into an appropriate rack location and the put away operation is completed by scanning a barcode that represents the location. This step can sometimes result in the wrong location barcode being scanned in. The proposed solution was a lift truck fitted with a vehicle –mounted computer as well as a mobile RFID reader at the mast area. Each individual shuttle channel is lined with two RFID location tags at the beginning and at the end of each channel also the shuttle machine is equipped with an RFID reader. Therefore, when a forklift operator picks up any pallet that is fixed on by RFID tag, the pallet with the tag is automatically detected on the screen and when the pallet is placed in the wrong location, an alarm will give an alert. In addition, each pallet location will have a unique ID along each channel, will show its own information, and will be monitored to the warehouse supervisors to transfer and distribute sites and instead of printing the list of information in the process of selecting paper. After that, sort the pick list and distribute it to the warehouse operator, where the items are selected according to the pick list and deselected manually, then do the process of updating the pick status and

migrating them manually to the WMS. The proposed solution was that the lorry automatically reveals the pallet and location tag and promptly validates whether the transfer out operation is permitted. When the pallet is brought to its new location, the system already validates the pallet against its new location and then automatically performs the update. In regards to the picking process, the pick list is then sorted out and distributed to the warehouse operator. Items are picked according to the pick list and manually checked off in the paper pick list; this pick status is later manually updated to the WMS. The proposed solution was pick tasks will be automatically distributed to the lift trucks' computer screens eliminating the need for paperwork during a full pallet pick the system scans the pallet and location tags to ensure the correct place is being picked and updates the pick action affirmation to WMS. In a real-time-based information system when loose items are to be picked, the system reveals and confirms the source pallet and location and transfers the picked inventory to a destination pallet. The pick task confirmation is also updated promptly. For transfer to shipment zone, similar to the transfer in process and instead of handover is manually processed between two parties. The proposed solution was, when a picked pallet passes through the RFID handover gantries the zone transfer is automatically detected and recorded, and when a pallet that has not been picked is illegally transferred out, an alert is triggered.

5. Discussion of results

In conclusion, our forecast results for the third-party logistic providers sample have shown an enormous growth that would reach 38.5% by 2030. Therefore, we have proposed RFID as a business process reengineering technique to mitigate with the coming growth instead of expansion that would cost a huge amount of money due to land costs. Moreover, we have noticed through our visits that the space utilization and warehouse capacity is very high and most of the warehouses are seeking expansion or employing additional operators to handle the current growth.

There are several benefits to be expected from using this technology system including non-line of sight (NLOS) functionality, product or unit level tracking (ULT), and location-based asset tracking. Knowing that RFID technology provides NLOS tracking through the radio frequency process. For example, through this transmission, the warehouse manager/operator can keep track of multiple packages that are stacked together without having to stir packages to search for important barcodes. In addition, the RFID technology is based on providing the possibility of locating each item or unit with its own unique numbering, which makes ULT possible by providing comprehensive coordination and numbering of goods and different units within warehouses, in addition to that RFID works on the process of tracking assets through Source linkage. Generally, by using this efficient method, distinct radio emission sources are identified where RFID technology can help smoothly manage the flow of goods into and out of the warehouse and improve the speed of production of products at the receiving dock, which leads to a significant and impressive improvement in efficiency.

When RFID technology is used, there is no need to place products and pallets in predetermined locations, as this technology reduces “honeycombing” and helps create a more flexible and smooth storage environment. Thus, the RFID technology is used with WMS in measuring productivity in different warehouses, facilitating the process of returning damaged or non-conforming goods because of its damage (not for direct sale), as well as improving the use of dock utilization and put-away/stopping rates. In addition, the RFID technology works to enhance the accuracy of implementation, raise the efficiency of work and workers, reduce errors in shipping operations, and raise the levels of accuracy in them. This technology also eliminates repetitive and tiring traditional manual physical inventory processes and reduces the number of cycles and allows for optimum utilization of various resources. There is consensus from many researchers and practitioners in SCM literature, which point out using RFID technology provides leverage capabilities in SCs. Through a unique identification of different products, intelligent communication processes, provision of the necessary information about products in real-time and the possibility of linking them with modern technological techniques that will raise the levels of performance and comprehensive storage procedures, as shown as Fig. 10.

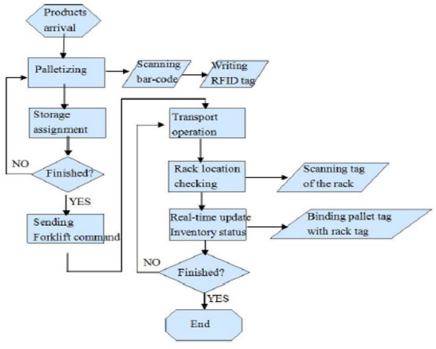

Fig. 10: Flow chart of storage procedure

(Source: Adapted from Li *et al.*, 2011)

6. Conclusion and Future Research

In this part, the conclusions reached in this research will be presented by answering the questions of the study in addition to relying on the literature, the interviews that were conducted, and the answers of the target interviewees and their analysis. Using RFID technology works to provide many contributions and benefits in different SCs through its advanced characteristics. Such as ease of wireless and indirect communication with different products in warehouses, ease of linking them with other advanced technological techniques, accurate and unique identification of different products in warehouses, providing accurate and necessary information about different products in the real-time based system. Additionally, it provides an increase in revenues and profits, reduces total costs, improves operations and various logistical activities. Also, it works to improve service levels and quality, decreasing human error, increasing productivity efficiency, identifying and placing goods in their correct place on the shelves, and there is no need for line of sight, optimizing performance, increasing speed, precision, accuracy, and visibility.

6.1 Limitations and future research

This research focuses on the internal warehouse activities. We did not consider the whole supply chain entities, such as raw materials providers, distribution, transportation management, are still left for further discussion. In addition, most firms today face more obstacles and challenges in their business decisions in adopting and using modern technology, such as RFID, so firms are trying to search for how to measure risks or costs based on the benefit achieved through adopting such technology. This requires a study on the RFID return of investment.

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Appendix

Interview Questions Sample

- From your point of view, to what extent is RFID technology applied in supply chains?
- In your opinion, what are the logistics functions and activities in which RFID technology is used in supply chains?
- What are the most important benefits that are obtained in the warehouse when RFID technology is used?
- A Detailed elucidation of the receiving & put-away processes; methodology, durations, employees needed & frequency?
- A detailed elucidation of the picking processes; methodology, durations, employees needed?
- What is the type of the racking system used and how does it incorporate with the type, frequency and amount of SKUs received?
- How much is the yearly throughput?
- What is the current warehouse utilization?
- What is the frequent employee utilization; pallet per hr.?
- How many employee used?
- What is the frequency of human errors and how much does it approximately cost?
- Is there any information system used?
- What is the working hours?
- Have you ever thought about installing RFID system? Why and why not?
- How can RDFID benefit you internal processes?

What implication does the RFID have?