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RFID-enabled Warehouse Process Optimization in the TPL Industry

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Keywords

RFID, business process, Living Lab, pilot, TPL industry

Disciplines

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RFID-enabled Warehouse Process Optimization in the TPL Industry

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Abstract

Using the value chain model and a longitudinal real-world case study of a third-party logistics (TPL) supply chain, this study provides support for the enabling role of RFID technology in effecting warehouse process optimization. Furthermore, the findings of our study reveal the RFID technology implementation costs as the key inhibitors factor of RFID widespread adoption and usage among suppliers.

1. Introduction

Defined as a wireless automatic identification and data capture (AIDC) technology[1], radio frequency identification (RFID) is emerging as a new interorganizational system (IOS) that will transform supply chain business processes and practices [2-4]. Despite this high potential of RFID as an enabler of supply chain transformation, the related literature shows a lack of empirical studies that provide support for the enabling impact of RFID technology in improving outbound logistics activities such as warehousing, order fulfillment, transportation, and distribution, which are performed by third-party logistics (TPL) firms in supply chain management. This study intends to bridge this knowledge gap, by drawing on an earlier study on the RFID research agenda [3], as well as on a longitudinal real-world case study in a TPL supply chain. In this regard, this study examines the following three research questions:

1. How are business processes and work systems changed due to RFID at all points in the value chain?
2. To what extent should the initiators encourage the process redesign in their trading partner facilities?
3. How does RFID change the job descriptions and work roles? (p. 99)

The rest of this paper is structured as follows. Section 2 presents a review of the literature on the value chain model for value creation through an integrated flow of materials and information, the importance of information technology in the value chain, outbound logistics in the TPL industry and the role of RFID technology as enabler of warehouse

process optimization. Section 3 presents the research methodology and a Canadian TPL supply chain studied. Section 4 presents the results obtained and discusses the lessons learned. Finally, Section 5 provides a conclusion including our research limitations and future research directions.

2. Background and context of the study

2.1. The value chain model

The value chain model was proposed by [5] in his book “Competitive advantage: creating and sustaining superior performance” as a means to analyze and describe all activities conducted within a company to create the value and competitive advantage that will support its competitive position in the industry. The model’s process view [5] shows the existing task interdependency and implies that an integrated flow of materials and information is the key to value creation within the enterprise value chain. The model identifies five primary activities: inbound logistics, operations, outbound logistics, marketing and sales, and service, as well as four supporting activities: corporate infrastructure (i.e., leadership), human resources management (i.e., education and training), technology development (i.e., IT to support the value chain activities), and procurement (Figure 1).

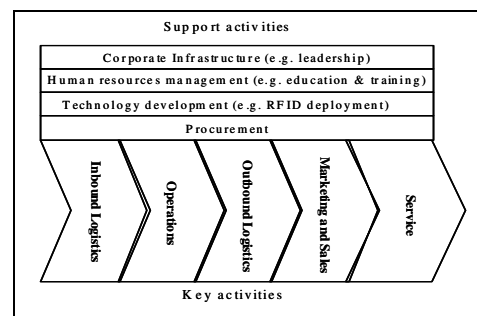


Figure 1. The value chain model

The focus of our paper -warehousing- is an integral part of Outbound Logistics, which performs essential activities such as inventory management, order

fulfillment and transportation that are required to get the finished product -an output of Operations- to the end customers.

Primary activities are thought to contribute directly to the creation or delivery of a product or service, and hence to business value creation, while secondary activities are mainly used to support and enhance effectiveness and efficiency of the primary activities [5]. To the firm, the costs of realizing the product or service, and, therefore, profits, depend on the activities to be carried out within the value chain [5]. More importantly, realizing a profit margin and a competitive advantage will depend on the level of optimization and coordination of all interdependent activities in the value chain [5]. In the literature, it is commonly assumed that the use of network information technologies, such as electronic data interchange (EDI) and RFID, can help the firms achieve these value chain objectives. However, the literature does not provide any empirical support for the commonly held assumptions.

2.2. The value chain model and information technology

The value chain model is recognized as a useful tool that allows managers not only to analyze, redesign intra- and inter-organizational business processes to improve firm efficiency and effectiveness [6], but also to understand how Information Technology (IT) may affect the firms competitiveness [5]. To [5] “technology is embodied in every value activity in a firm, and technological change can affect competition through its impact on virtually any activity” (p. 166). Several ITs have been used to support value chain primary and supporting activities and linkages with suppliers and buyers. For example, e-commerce technologies may served as means of integrating the value chain in order to reduce costs and to react more rapidly to changes in an unstable market [7], to facilitate intra- and inter-organizational business process reengineering, and thus improving information sharing [8] and the coordination of decision making [9] and enhancing the organization’s comparative efficiency [10] and benefits [3]. However, the level of IT adoption and usage within the value chain depends on various factors such as IT characteristics (e.g., complexity, relative advantage), firm characteristics (e.g., firm size and readiness) and environmental characteristics (e.g., competitive pressure) [11], the level of organizational change to leverage the IT capabilities [12].

With regards to RFID technology, its characteristics such as multiple tags items reading, more data storage capability and data read/write

capabilities and no line of sight may act as facilitators of its widespread adoption and usage, while its perceived complexity and cost may constituted the inhibitors factors.

2.3. Outbound logistics and TPL industry

A TPL service provision is defined as “a relationship between a shipper and a third party which, compared with the basic services, has more customized offerings, encompasses a broad number of service functions and is characterized by a long-term, more mutually beneficial relationship” [13] (p. 35). Today the TPL industry appears as a viable solution to the market globalization, increased competition, cost pressures and an increasing use of outsourcing [14]. The growing importance of the TPL industry is highlighted by the results of multiple survey studies. [15] found that, among more than 1,500 logistics and supply chain executives, almost 82% of the respondents were using TPL services. Similarly, in a more recent study, [16] found that 70% of firms in North America, 73% of firms in Europe, and 75% of firms in Asia Pacific were using TPL services for their warehousing activities. In addition, TPL is more and more considered as a strategic tool for the IT-enabled supply chain to reduce environmental uncertainty and improve logistics management efficiency. Indeed, IT capabilities play a vital role in achieving the integration of logistics services provided by TPLs. For example, [16] found that 91% of TPL users will outsourced their web-enabled communications and visibility tools while 83% of them will do the same as regards warehouse/distribution center management. Finally, the TPL industry is viewed as a lead user of RFID technology.

2.4. Warehousing processes and RFID technology potential

In an economic context where the growing development of information technologies has been generating unprecedented repercussions on the management of activities within warehouses, it goes without saying that the use of a centralized inventory management, for example, could lead to an increased productivity and short response times of the warehousing systems, and that “shorter product life cycles will imposed a financial risk on high inventories and, therefore, on the purchase of capital intensive high-performance warehousing systems” [17] (p. 519).

To categorize warehouses, say [18], there are three main perspectives to be considered: the processes, the resources, and the organization (p. 516). The processes are the different steps through which a product will

pass through in the warehouse; they can be divided in four distinct phases: (i) the receiving process, which is the first step the products go through in a warehouse. This stage usually involve the checking and/or the repackaging of the products in the various storage units before they are moved to the next process; (ii) the put-away process, which consists in moving and placing the products into their specific storage location so as to make it easy for the picking clerk to retrieve them; (iii) the picking process, which involves the retrieval of the products from their storage locations in order to consolidate a customer order. This process is considered as the most “labour-intensive and costly activity for almost every warehouse” and could account for up to 55% of the total warehouse operating cost [19]; (iv) the shipping process, which involves the checking, packing and loading of the products in the transportation unit in order to bring them to the customer facilities. The efficiency and effectiveness of these processes will heavily depend on both the better management of the interdependency between them, the resources available and the organization of the warehouse. More precisely, the resources involve all means, that is, equipment such as the storage unit (e.g., pallets, boxes), the storage system (e.g., simple shelves, automated systems, automated cranes or conveyors, pick equipment), a warehouse management system (WMS) (to control of the processes within the warehouse), a material handling equipment to prepare the retrieved items (e.g., sorter systems), and the personnel needed to operate the warehouse. Finally, the warehouse organization involves all the planning and control procedures that are used to run the system. For example, during the picking process, a routing policy may describe the sequence of retrievals and the road to visit the retrieval locations within the warehouse [18].

Recently, an increase number of researchers have demonstrated that RFID technology could have important impacts on the four above mentioned warehouse processes than any other technology. These researchers include: [20], who argue that RFID technology could reduce the put-away labor cost by 20 to 30% and the picking labor cost by some 30 to 50%; [21], who, through a pilot study, demonstrated that RFID could transform the warehouse processes – which may, in turn, facilitate collaboration practices in the supply chain such as collaborative planning, forecasting and replenishment and vendor managed inventory. For example, RFID technology may automate the verification activities involved in the shipping process, thus reducing potential errors during the realization of the said process; [4], who argue that the impacts of RFID on the warehouse processes may allow an “intelligent supply chain management” through the emergence of the so-called “intelligent

processes”–which are processes that can be automatically triggered without any human intervention; and [22], who show that RFID enables the automatic input of receipt in the supply chain system during the receiving process, which allows real-time checking of bin availability during the put-away and picking processes and reduces the process time of these processes. Despite the high potential of the RFID technology, the literature is yet to provide real- world longitudinal studies to test these assumptions. The RFID-related literature shows that there is a knowledge gap to bridge and that and this research was necessary.

3. Methodology

This paper is part of a larger study conducted in Canada to improve our understanding of the impacts of integrating RFID technology in a TPL supply chain. A value chain perspective [5] is adopted since RFID adoption and usage is mainly product-driven [23] and involves the study of the impacts of RFID on the interdependent activities related to the management of telecommunications stationary batteries of a specific TPL supply chain (Figure 2).

3.1. A Canadian TPL supply chain

The TPL supply chain studied in Canada is involved in the management of telecommunications stationary batteries (Figure 2).

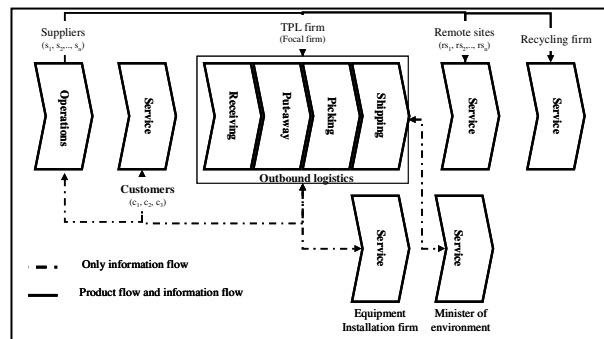


Figure 2. TPL supply chain

The focal firm is a Canadian-owned medium-size TPL service provider, with annual revenue of nearly US\$23 million and 52 full-time employees and owns a large distribution centre in Canada and warehouse facilities in the United States of America (USA). The company provides a variety of services such as storage, transport and customs clearance fees. Its Canada-based distribution centre, where the study was conducted, is used to store telecommunications batteries from various suppliers. The company is in charge of (i) shipping new batteries to different customers' remote

sites based on their needs, (ii) collecting used batteries, and (iii) bringing them to the recycling plant. It relies on set of IT systems to conduct its intra- and inter-organizational business processes - which range from the very basic practices (e-mail, fax, and paper-based system) to the sophisticated ones (bar code systems, in-house warehouse management system, RFID-enabled transport management system, B2B Web portal). In addition, the firm often uses the Canadian postal services to communicate with its supply chain stakeholders. However, the firm primarily uses its paper based system to track and trace batteries analyzed in this study. Nevertheless, the TLP firm is already using RFID technology. Indeed, in 2005, the firm had its first experience with the RFID technology when it started providing a “Slap & Ship” RFID solution service to its customers in order to meet RFID mandates from their trading partners. Later in the same year, the firm started deploying a RFID-enabled truck tracking solution so as to have better visibility on its “truck in transit”. According to the management board of the TPL Company, the use of RFID technology as an enabler of telecommunications stationary batteries management is a “logical next step” in their IT innovation process for value creation.






3.2. Research design and data collection methods

As the main objective of this study is to improve our theoretical and practical understanding of the impact of RFID technology in real-life contexts, the research design clearly fall into the realm of exploratory research. Subsequently, a longitudinal case study was conducted between September 2007 and April 2008 in a TPL supply chain following two main phases. [24] defined the case study as “a research strategy which focuses on understanding the dynamics present within single settings” (p. 534). This research strategy allows to focus on emerging phenomena and eventually induce theories [25], and is recognized by many researchers as an appropriate approach to answer research questions such as “why” and “how” things are done [26], and is therefore suitable to study the impact of RFID technology on the warehouse processes of a TPL industry, where research and theory are at their early and formative stages [25].

In the first phase or the RFID technology opportunities exploration, both qualitative and quantitative data were collected through multiple sources such as several interviews, three focus groups, multiple on-site observations, RFID workshops, organizational documents and RFID technical papers in order to understand the dynamics within the supply chain. For example, on-site observations allowed us to

map existing processes, interviews with operational staff and managers on “how and why things are done?” provided more exhaustive information that can help to solve possible inaccuracies in our mapping. Furthermore, a business process analysis tool called “ARIS Tools”, which is based on the Event-driven Process Chains (EPC) formalism [27, 28], was used to understand, represent, and “map” the existing intra- and inter-organizational processes into a current model (as-is), and therefore identify bottlenecks and areas of opportunities when using RFID technology. Using this current model as a guide, we performed an analysis of business and technological information requirements together with key stakeholders involved in the warehouse project. In addition, the tool enables managers involved in the project to make decisions about the management of RFID-enabled business processes by looking for example, the impact of the technology on resource utilization, IS-integration and information flows. This analysis enabled us to generate various plausible scenarios of business process optimization, integrating RFID into the warehouse processes. These optimization scenarios were discussed with the stakeholders during RFID workshops.

Table 1. Elements of EPC model [29]

Element	Description
	An “event” describes the situation before and/or after a function is executed, and may correspond to the post-condition of one function and act as a pre-condition of another function.
	A function corresponds to an activity (e.g., task and process step), which needs to be executed.
	The “AND” connector allows (i) the flow of the process branches into two or more parallel paths; and (ii) all the events must occur in order to trigger the following function.
	With the “OR” connector (i) one or more paths may be followed as a result of the decision; (ii) each event, or combination of events, will give rise to the function.
	With the “XOR” connector (i) one, and only one, of the possible paths will be followed; (ii) one, and only one, of the possible events will give rise to the function.

In fact, “ARIS Toolset” allows a global definition, mapping, analysis, optimization and implementation of business processes. This formalism offers a logic

representation of activities in a network of multiple organizations through the alternative use of events, functions and connectors to specify the routing logic based on the required decision rule [27] (Table 1). The use of the “Aris Toolset” in the project enables all stakeholders involved to understand the impacts of integrating RFID technology on business processes both at the focal firm level and at the network level. Moreover, the EPC formalism is considered as a viable means to study a collaborative e-business process [30], and more recently, the impacts of RFID technology on SC-enabled business process transformation [31]. And finally in the second phase, two most plausible scenarios of RFID-enabled supply chain were being chosen, assessed and discussed in the RFID solution provider laboratory by key project stakeholders through the “Living Laboratory” approach. Then, one scenario is retained to be implemented and monitored during a pilot project in the focal firm warehouse. In fact, “Living Laboratory” approach was planned to support various research settings, including the simulation of business experiments and the use of the laboratory over an extended time by all key RFID project stakeholders for “self-trial” learning, joint problem solving, interaction, knowledge generation and exchange among all key project stakeholders [32].

4. Results

We now present and discuss the results of the RFID implementation in relation to the TPL warehouse process optimization and the future RFID-enabled warehouse optimization that is plausible, but has not been implemented largely because of the lack of stakeholder investment.

4.1. RFID-enabled warehouse process optimization

The first scenario of the RFID-enabled warehouse process optimization (section 4.1.1) required the RFID tagging of products in the TPL warehouse. As for the next phase, it assumes that this tagging activity is conducted in each supplier’s facilities, and represents, from the TPL firm perspective, the best scenario of RFID adoption in the TPL supply chain (section 4.1.2). However, the suppliers were unwilling to make the initial RFID investment required. In consequence, the best scenario for the warehouse process optimization could not be chosen for implementation. Instead, the first scenario was implemented and monitored in the pilot project at the TPL warehouse.

4.1.1. Current RFID implementation focus: RFID

as enabler of incremental change on the picking and shipping processes (s1). Figure 3 presents the current picking process (“as-is”), while Figure 4 presents the incremental redesign process of the same process when using RFID technology (“to-be”). Figure 5 presents the current (“as-is”) shipping process and Figure 6 the incremental redesign of the shipping process integrating RFID technology (“to-be”).

Based on the analysis of the current processes (“as-is” picking process in the Figure 3 and “as-is” shipping process in Figure 5) and on the incremental change when using RFID (“to-be” picking process in Figure 4 and “to-be” shipping process Figure 6), the following observations are made: (i) the picking process involves two human resources (HR) and the shipping process one human resource; (ii) the main activities of the HR in the picking process (Picking-clerk-1) include the processing of information (e.g., manually print the picking order (e-Pick) that is used in this process, while the second HR deals with physical activities in the process (e.g., Picking the quantity of battery on the p-Pick), and generates and prints the manifesto (s-Manif) marking the end of the process.

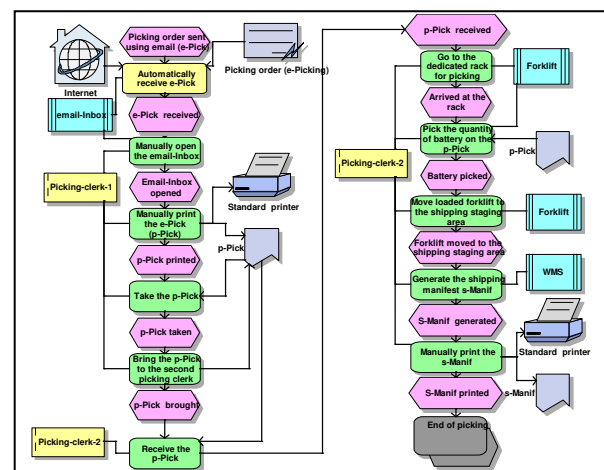


Figure 3. The current picking process

This manifesto constitutes the link between the picking process and the shipping process.

In the shipping process, a single HR needs to manage all physical activities (e.g., Drop battery into the truck) and informational (e.g., Take the s-Manif) activities in the process. In both cases, the information used is mostly paper-based. On the other hand, there is no means to verify that the type of batteries that is being picked corresponds to the one being ordered. The smooth running of these processes heavily depends on the judgment of the HR involved. For example, there is no mechanism to know for sure that the batteries

that are being shipped are those featuring in the manifesto. This situation often leads to a shipment mismatch, and thus increasing transportation costs as the truck driver needs to bring back the shipment and reschedule a new one, which also affects customer service delivery. Resolving this situation is one of the goals of RFID technology adoption by the TPL management board when it comes to batteries management.

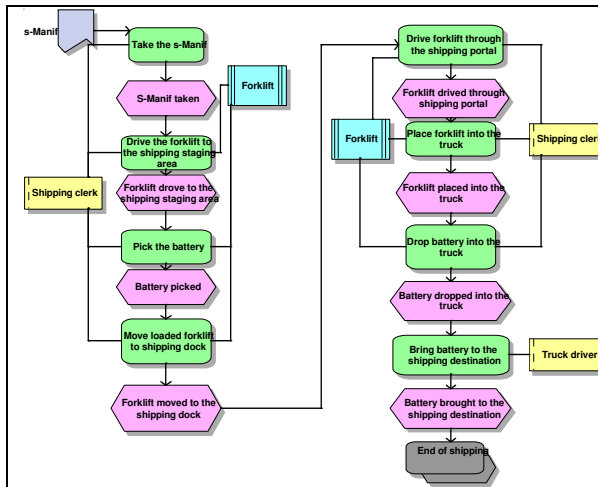


Figure 5. The current shipping process

The picking process with the incremental change from RFID technology is similar to the current (“as-is”) picking process with a new no-value activity, which is “manually print the number of RFID tags (n-Tags)” – that the first picking clerk (Picking-clerk 1) needs to pick the order using a RFID printer. In fact, because the suppliers of the TPL firm are not yet involved in the project, the TPL needs to conduct the tagging process. Now, not only is the second picking clerk responsible for picking the quantity of battery on the p-Pick to bring them in the shipping staging area, but he is also in charge of all shipping activities. Indeed, because the integration of the RFID infrastructure with the firm’s ERP and WMS allows the automatic validation and generation of the manifesto, all picking activities related the manifesto are now transferred to the shipping process and are automated all together, and thus increasing the level of electronic integration between the picking and the shipping process. One implication of this new level of electronic integration is that the picking and the shipping processes should henceforth be carried out when the truck is ready to carry the shipment to the remote sites, which therefore increases the use of the warehouse staging area.

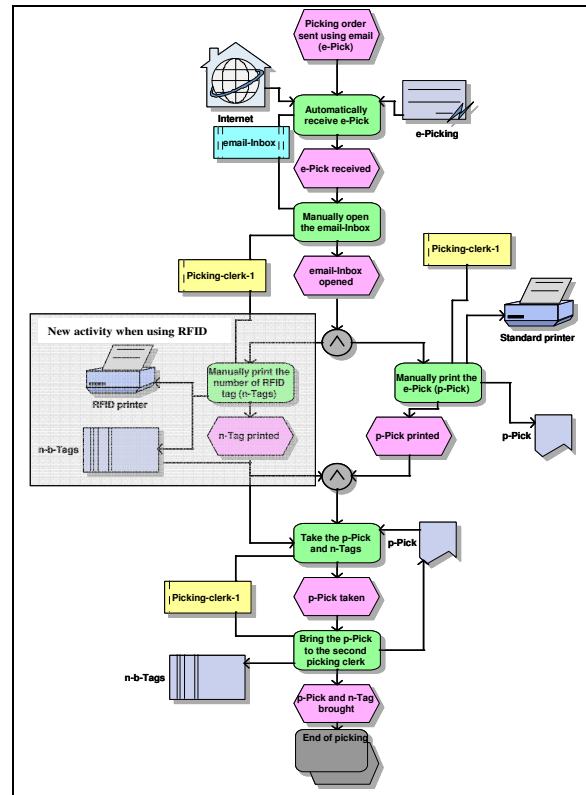


Figure 4. The picking process with incremental change when using RFID

In the “as-is” shipping process is triggered by the shipping manifesto, and followed by the physical picking of the batteries from the shipping staging to the truck by the shipping clerk. In the case of the shipping process with incremental change when using RFID, the following steps can summarize the execution of the process (Figure 6): (1) When the p-Pick (paper-based picking list) and the n-Tags (number of RFID tags required in the picking list) are received by the second picking clerk (Picking-clerk-2), he drives the forklift to the dedicated picking rack so as to pick the requested number of batteries and move the loaded forklift to the shipping staging area where he manually attaches the RFID tags to the batteries (Figure 7 (a)). Once the tagging process is finished, he drives the forklift through the shipping dock equipped with an RFID reader (RFID portal) (Figure 7(b)). (2) As soon as the picking clerk drives through the shipping dock equipped with an RFID reader (RFID portal), an automatic reading of all RFID tags is performed, followed by a linking of the data collected from the tags to the shipping order for automatic match

validation (Figure 7 (c)). (3) If there is a mismatch, owing to the business rules that are configured in the RFID middleware, an automatic message is sent to the clerk to stop the process for further verification. Otherwise, a set of operations are performed in parallel (e.g., automatically send an e-ASN, automatically update inventory into the WMS, automatically generate and send the manifesto, etc.) while placing the forklift into the truck to drop the batteries.

(4) Once the batteries are dropped into the truck, the truck driver leaves the TPL facility to bring the batteries to the shipping destination while the location-based system (LBS) is automatically initiated for “in-transit” visibility.

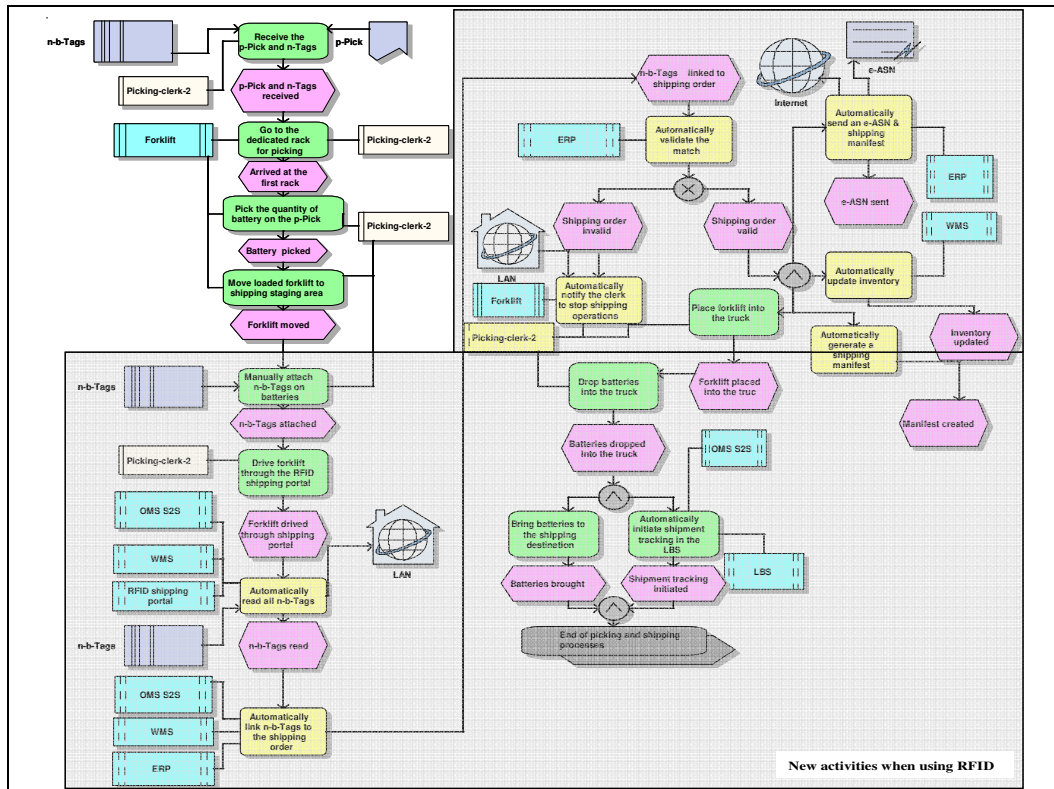


Figure 6. The shipping process with incremental change when using RFID

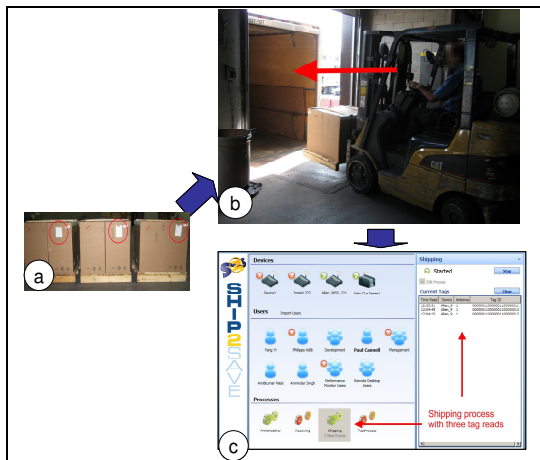


Figure 7. Steps related to automated picking and shipping processes

4.1.2. Future plausible RFID implementation: RFID to merge the existing picking and shipping processes (s2). Figure 8 presents the case of a merge of the picking and shipping processes when using RFID technology.

In this scenario, which is considered as the best RFID implementation scenario by the TPL firm, the RFID baseline infrastructure is build in the suppliers facilities (e.g., for the product tagging, RFID information exchange, etc.), which is then gradually extended to the rest of the supply chain stakeholders. With this scenario, all batteries are now RFID-enabled prior to their shipment to the TPL focal firm warehouse and the rest of the supply chain, and thus increasing the level of supply chain electronic integration and the RFID network externalities.

By contrasting this scenario with the current picking process (Figure 3) and shipping process (Figure 5), the following observations allowed us to analyze the impact and understand the resulting opportunities. Now the picking and shipping processes are performed jointly as a single process and involve only one HR (in opposition to 3 HRs before), all paper-based activities being now cancelled, redesigned or automated. This single process is triggered by an electronic picking order (e-Pick) sent by the customer IS to the TPL WMS and ERP (this is the case of inter-organization process and IS integration). More precisely, the following steps can summarize this transformation scenario:

automatic match validation. (4) If there is a mismatch, owing to the business rules that are configured in the RFID middleware, an automatic message is sent to the clerk to stop the process for further verification. Otherwise, a set of operations are performed in parallel (e.g., automatically send an e-ASN or update inventory into the WMS, etc.) while placing the forklift into the truck to drop the batteries. (5) Once the batteries are dropped into the truck, the truck driver leaves the TPL facility to bring the batteries to the shipping destination while the location-based system (LBS) is automatically initiated for the “in-transit” visibility.

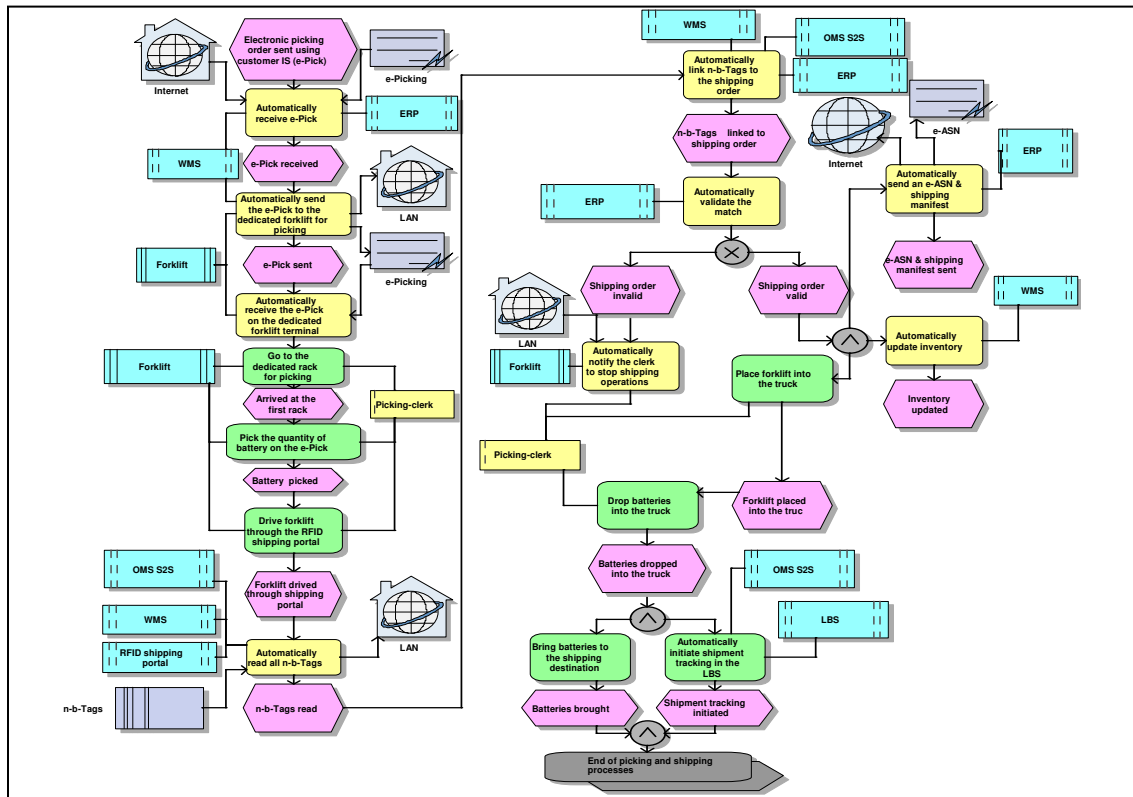


Figure 8. Merge of the picking and shipping processes using RFID

(1) When the e-Pick is received by the TPL WMS, based on business rules in the system, an automatic message with the e-Pick is sent to the dedicated forklift terminal for picking. (2) When the message is received, the picking clerk goes to the dedicated rack display on the forklift terminal to pick the requested number of batteries. (3) As soon as the picking clerk drives through the shipping dock equipped with an RFID reader (RFID portal), an automatic reading of all RFID tags is performed, followed by a linking of the data collected from the tags to the shipping order for

Besides, an analysis of time required to perform activities related to the tracking and tracing of batteries in the picking and shipping processes shows that in the case of incremental scenario (s1), the total time of the picking and shipping processes is decreased by 17% compared to current situation (“as-is”). But with an increase of around 133% for the picking process mainly due to the introduction of no value added activities such as manually print the number of RFID tags and manually apply them to the batteries. In the second scenario (s2), we have an improvement of 83%

compare to the “as-is” situation (Table 2). However, this high level of savings can only be achieved if the RFID tagging process is done by the supplier.

Table 2. Potential time savings for information related to the track & trace of batteries

Process (Time in seconds)	“as-is”	s1	s2
Picking per delivery	360	840	120
Shipping per delivery	720	60	60
Number of annual delivery	800	800	800
Total annual time	864000	720000	144000
% Annual time savings		17%	83%

5. Conclusion

In this paper, we presented the preliminary results of a pilot project of the RFID-enabled warehouse process optimization. From the TPL firm’s perspective, one of the important research results is that the suppliers were reluctant to adopt the RFID mainly because their initial investment, required by the TPL firm, has produced the minimum level benefits for themselves, which has a cascading effect on the minimum level business benefits realized by the TPL firm. The first scenario discussed in this paper explains these insights, which were presented in Figure 4 and Figure 6. These research findings provide support for the important negative impact of the cost issue on supplier RFID adoption, and are consistent with the results of prior research by [33]. Like other networks technologies, the study shows the importance of increasing the positive RFID network externality effects by promoting the buy-in for wider RFID adoption and use among all TPL supply chain stakeholders[34]. Moreover, our results are consistent with prior studies on the importance of a process view during IT implementation [12, 35], and recent studies on RFID technology [1]. In fact, [35] observes the value of the process view, by stating that the main organizational issues, which may emerge during the implementation of IS projects, are better understood and managed as “they often enact as a set of critical factors in project dynamics, and ultimately lead to a project success or failure”(p. 434). Finally, the study confirms the capabilities of RFID technology as an enabler of transforming the existing picking and the shipping processes in real-world setting, which is consistent with prior studies on RFID technology [21, 36]. Using RFID technology, the TPL firm improved the internal control of its warehouse. For example, the

real-time verification of shipments reduced the existing shipments mismatch during the execution of the shipping process which resulted in the reduced transport costs which are traditionally associated with shipment mismatch. This benefit realization by the TPL firm through RFID use is consistent with prior studies on improved organizational coordination and control mechanisms due to the technology [3]. This study presents a limitation in the sense that it only focuses on the impacts of RFID on the picking and the shipping outbound logistics processes in a single warehouse. Further studies are needed to assess the impact of technology in the supply chain in a real context and to develop tools and frameworks to calculate the return on investment of RFID projects at organizational and supply chain levels.

6. References

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