Critical management issues for implementing RFID in the Fashion Industry Supply Chain

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Abstract: Radio frequency identification (RFID) technology offers attractive ways to improve supply chain efficiency through greater coordination between marketing and manufacturing. RFID enables real-time tracking of items, safety monitoring and automation of warehouse operations, which leads to increase in sales volumes and improved profitability for suppliers and retailers. With the growth of RFID deployments in the fashion industry, more complex and ambitious projects have been developed in the last years. The great variety of applications that RFID technology can offer has been exploited by retailers and manufacturers to increase the efficiency of one or more supply chain processes. Although several RFID research publications focused on various applications of RFID there is a dearth of review of the literature on the application of RFID in fashion products manufacturing and retailing. Hence, an attempt has been made in this paper to review various applications of RFID in such industry with the related critical issues management. Furthermore, this paper aims to propose a framework for RFID implementations in the fashion supply chain. The aim of this research is to support practitioners and managers in evaluating a priori the complexity of their supply chain processes in order to achieve the highest benefits from RFID implementation; indirectly, this approach is also expected to increase the success of RFID-based project implementations while reducing the uncertainty in terms of performances and economical results.

Keywords: RFID, fashion, logistics, retail, track & tracing

1. Introduction

The adoption of RFID for process optimization had a boom between 1999 and 2003 when companies of pharmaceutical, defense and other industries realized the vast benefits of this technology. Nonetheless, the high costs of the first tags, readers and middlewares, the technology issues and the limited system integration eclipsed the advantages of RFID and key decision makers were reticent to embrace this technology.

Identifying products by using a tag, which allowed to store simultaneously an electronic product number and other data, was clearly disruptive for the "barcoded" industries but memory sizes were still limited for such high costs. Providers of electronic components gradually evolved their products, offering higher storage capacity and better read rates, in order to expand the emerging but promising market.

Thereafter, also providers of electronic instruments and software sustained this development by expanding their product portfolios (more types of RFID readers - fixed or mobile: tunnels, gates, roller conveyors, handhelds, etc.) and by implementing more flexible solutions able to be integrated with other systems.

In the meanwhile, the technology was gaining reliability and many cases of success were published: the pilot projects of Walmart, Woolworth UK, the GAP and CVS.

The technology advancements allowed driving more supply chain deployments in various industries: Automotive (Ford, Chevolet Creative Services), food (United Biscuits), semiconductor (Fluoroware Inc), port (Port of Singapore) and consumer goods (Unilever).

Consequently, the wide variety of processes in which RFID was applied caused its pervasiveness to explode in the last years: RFID now supports disruptive transformations, from real-time data sharing for more integrated supply chains to customer experiences based on RFID.

The adoption of RFID in the fashion supply chain was predictable: the reduction of lead times, faster distribution and real-time data sharing are essential features to increase the competitiveness in an industry with short life cycles, high variable demand and wide ranges of products. Furthermore, most of the product categories in this industry (i.e. apparel, leather goods, silk accessories, shoes) are both technologically and economically compatible with RFID: the items are typically made with not hostile materials for RFID technology and their high average value can easily and profitably tolerate the cost of item-level tagging.

This article will describe more in detail how the peculiarities of these processes outline consequent challenges either for the supply chain management when implementing RFID,

than for the attempt to formulate a 'one-size-fits-all' RFID solution to optimize comparable processes.

2. Literature review

RFID assets have evolved gradually adapting to the variety of applications and overcoming numerous issues. This continuous improvement is still running, as far as more ambitious objectives and higher performances are expected, RFID deployments are also facing new challenges. The aim of this section is to catalogue some RFID applications in the fashion industry and, furthermore, to evidence from literature some relevant aspects and critical issues in order to structure an approach to implement RFID in one or more processes in the fashion supply chain.

Azevedo, S.G. et al (2014) exposed five cases of study by cataloguing the implementations' features such: tag positioning, tag placement phase, used readers, tag reading phase and context, and benefits to the process. One main finding of this case study stated that the main driver that led to deploy RFID within the companies was the identification of inefficiencies in several operations.

Lee, C.K.H. et al (2013) evidenced that the garment industry is lacking real-time information to monitor the actual production performance and proposed a real time RFID-based Resource Allocation system for garment manufacturing. The crucial role of real-time data was also underlined by Majeed, M.A.A. et al (2017). The author stated that using RFID to obtain real-time information will be an advantageous aspect and most compelling reason to implement RFID in a retail supply chain.

Bertolini, M. et al (2016) et al proposed a framework of Key Performance Indicators (KPI) enabled by RFID-based real time data in order to increase the value of the fashion supply chain by exploiting the tracking capabilities of RFID technology.

Wong, W.K. et al (2014) exposed some RF Systems: application scopes, benefits and role on supporting the decision making in the fashion supply chain.

De Marco, A. et al (2014) proposed as a structural modeling and simulation method to assess the economic impact of item- level RFID technology on retail operations for one fast fashion retailer. The author emphasized the benefits of RFID in the context of apparel and fashion where consumers perceive large quantities of items displayed on shelves as an indication of novelty and a major motivation for shopping.

Tajima, M. (2011) presented the findings from a research showing the impact of the relationship between small and large firms on the inhibition or spread of RFID within the apparel industry. The main findings of this work provide management insight in order to promote the adoption of RFID technology among manufacturers.

Hinkka, V. et al (2015) overviewed ten existing RFID tracking solutions in fashion and apparel highlights the specific needs and challenges for configuring the tracking solution in order to propose a typology for configurable RFID-based tracking solutions in the context of one fashion logistics company.

The impact on system performances related with the heterogeneity of garments' allocation areas in terms of environment and density, and the peculiar characteristics of products was evidenced by Rizzi, A. et al (2017) in a case of study on the implementation of an RFID-based real-time locating system at a fashion retailer.

The analysis published by Bottani, E. et al (2014) about the key business functions in a fashion company where RFID technology has the potential to make a significant impact, including logistics, procurement, operations and information, revealed that in the case study companies Distribution Centers (DC) and Retail Store's (RS) processes could be managed in several different ways. And that depending on the AS IS scenario, the impact of RFID implementation could be different. Furthermore, it was evidenced the difficulty of applying tags to clothes at the manufacturer's site due to the industrial processes such as washing and ironing that may be performed at this stage, as a peculiarity of the fashion supply chain.

Bottani, E. et al (2015) collect some publications about the use of RFID in the fashion industry covering topics related with the design of new RFID solutions and technology developments, of business models for RFID in fashion and RFID implementations.

Moon, K.L. et al (2008) established that fashion retailers showed concerned about the costs of RFID systems, the difficulty of systems' integration and about the lack of top management support and resistance by employees to try new technologies.

Nayak, R. et al (2015) underlines that part of the new challenges that RFID deployments are facing can be overcome with the technical developments and affirms that RFID will become a reality in fashion and textile.

About other issues related with supply chain management and RFID, Attaran, M. (2012) exposed ten critical implementation factors that can prominent influence the adoption of RFID, among which, a clear definition of business needs and benefits, the involvement of top management, a proper planning and scoping, partnership with competent technology providers, the integration with internal systems, teamwork and adequate staff training and involvement. Similarly, Chelliah, J. et al (2015) presented as a result of their work that planning, prioritization, technical integration, and understanding impacts and future implications were pointed out as essential in mitigating risks and were seen as key success factors in a paper in which authors placed at the heart of change management "people, process and technology" as guiding themes.

Also Ngai, E.W.T et al (2014) outlined a list of success factors for RFID-based system implementations, in which was emphasized the importance of selecting an appropriate vendor able to help the company to design and develop a more customized system according to its specific characteristics and operating environment, and leading to a

smoother implementation process. Furthermore, as lessons learned at managerial level from the case study on the improvement of garment manufacturing operations underlined the importance of both having clear objectives and obtaining users' acceptance.

An emphasis to the goals also by Lu, B.H. et al (2006), who stated that objectives must be well defined and clearly tied to the business goals and proposed a framework for the adoption of RFID. This framework contains the targeted applications, objective/action indications about barcode replacement, reengineering workflows and new process models, in order to avoid the risk of further maturing of the technology and to get ROI as quickly as possible.

A related work was published by Ferrer, G. et al (2010) in which the focus was to improve managerial decision making by building a conceptual framework that helps managers to understand key variables of RFID benefits service operations. Moreover, it is underlined that based on the appropriate performance objectives, managers should be able to select the right RFID application and provide the correct justification to senior management and stakeholders to secure their buy-in.

Kamoun, M. (2009) affirmed that good management practices and policies are decisive to guide the next generation of RFID systems to meet the operational and performance requirements (scalability, availability, manageability, privacy, security, seamless integration, robustness, adaptive, etc).

In the same way, Nath, B. et al (2006) also mentioned that the challenges extend to the important social issue of protecting personal data and user privacy as the tags become pervasive, and underlined the importance of developing effective solutions for collecting and managing data for the success of future RFID applications.

Likewise, Bhuptani, M. (2005) reinforced that the challenge consists in rethinking existing business processes or creating new ones to fully leverage the powerful, real time data collection capability offered by RFID rather than in applying the tag to the items. And expose the new set of challenges about data management and integration into existing systems and processes in order to increase benefits.

Buckel, T. et al (2014) developed a number of decision aids using the action research methodology in order to support practitioners in the resolution of issues like data quality, management attitude, internal resistance among their staff, complex system integration, faced during the implementation of productive RFID systems.

The persistent attention of these works to well defined goals, to data management and to the integration with internal systems, evidences the necessity to adopt tailored solutions and the risks of formulating a 'one-size-fits-all' approach when a company intends to implement RFID successfully.

Srivastava, B. (2010) supported the importance to underscore that a 'one-size-fits-all' approach is not allowed by the physics of RFID technology.

While Myerson, J.M. (2006) specified that no business process strategies are the same in scope and approach at site, package and network levels.

RFID strategy adoptions, which imply reengineering business processes, consequently could not be the same in scope and approach. This means that it is necessary a tailored solution in order to derive the most value for the emerging technology and then to develop an implementation plan that would bring in realizable ROI sooner.

Angeles, R. (2005) underlines that key decision makers will have to take into account the needs of their corporate environment, the needs of their valued trading partners, and the needs of the industry to which the firm belongs in making their RFID technology choice.

These needs will difficultly coincide for different companies reinforcing the previous statement.

This section has evidenced some features and critical issues of RFID implementations in the fashion supply chain from the literature. The next section intends to collect further information from case study analysis.

3. Cases of study

This section contains five cases of RFID deployments for process optimization in the supply chain in which authors' contribution was to support the fashion companies' managers along the whole implementation starting from the feasibility study of RFID technology and up to the deployment. As insiders the authors were allowed to experience the approaches, the mindsets and the scenarios of each of these companies thus gaining a wider perspective on the specific features.

Relevant features about the companies under study, all of them belonging to the luxury segment, are reported in Table 1.

The application in company A consisted in implementing the RFID technology along the supply chain starting from the stage of finished products' manufacturing by outside contractors, then during their transit by the Group warehouse and their next allocation to the wholesale and retail markets and, finally, for in-store procedures.

The main objective was to optimize the inbound process in the distribution center. The first step was to structure a detailed mapping of the business process. Then, for the TO BE scenario outlining, many considerations were taken into account: identifying a unique suitable tag type for such broad product portfolio (Only eyewear, cosmetics and perfumes were excluded - not in transit by the DC -) required a detailed test phase to evaluate the reading performances. Some of the test settings that were conditioned by the AS IS requirements were: specifications concerning the tag dimensions, the assets used during the tests, suitable tag placements, etc.

Table 1: Company's salient features

Company	SC Positioning	Products handled
A	Fashion brand	Apparel, Large and small leather goods, Shoes, Accessories (ties, belts, scarfs), eyewear, Perfumes, Cosmetics
B	Fashion brand	Large and small leather goods, Accessories (ties, belts, scarfs), eyewear.
C	Façonist /O.C	Large and small leather goods, belts.
D	Fabric maker	Fabrics
E	Confectionist	Apparel

Placing the RFID tag on the product's primary packaging, and not on the brand's tag attached to each product, was the trade-off that guaranteed good read rates for the various product categories while using a unique tag type.

To obtain higher performances, it was necessary the integration between the WMS (Warehouse Management System), the ERP (Enterprise Resource Planning) and the RFID system, while the outside contractors' systems were not integrated.

The case of the company B considered all product categories (excluded eyewear) and the application, even if covered the same part of the supply chain than company A, stablished different goals: traceability, logistic process optimization in the DC, anti-counterfeiting and customer experience. Furthermore, the company intended to extend the use of RFID tag for the internal warehouse operations, for the showroom management and for in-store operations. The first step was to structure a detailed mapping of the business process.

Afterwards, a solution for the accomplishment of such ambitious goals was studied and it was concluded that two RFID tags were required to cover these objectives: one embedded and the other one placed on the product's tag. The presence of two RFID tags for each product implied the necessity of introducing an association stage (required new: hardware, software and procedure). A test phase was conducted in order to evaluate the performances of the technology for the different product categories. The various tests were set following the packaging and shipping practices mapped in the AS IS analysis.

The level of integration of the various systems was similar to the company A: ERP, WMS of the DC and RFID, excluding outside contractors' systems.

The application of RFID in the company C included all product categories and the main objective was to optimize the logistic processes (inbound and outbound) in the internal warehouse.

As usually, a mapping of the process AS IS was structured and, subsequently, a test phase was conducted in order to define the type and the placement of the RFID tag according to the business requirements. The internal IT system was adapted to integrate RFID-based processes.

The case of the company D consisted in the item-level tagging in order to monitor the outsourced production progress and to optimize the quality control process. It was necessary to have RFID enabled equipment for QC. The most critical issue was to identify a suitable RFID tag which could resist the aggressive treatments applied to textile.

The company E adopted the RFID technology to achieve two main goals: first, to enable its customers (luxury fashion brands) the monitoring of the production progress. The second, to improve the warehouse shipments' accuracy.

Further details on the case study are reported in Table 2.a and Table 2.b.

Table 2.a: Case study

Comp.	Time	Modalities	Results
A	6 months	Process reengineering (P.R) Test phase	1mln tagged items Automated warehouse Ongoing
B	2 years	P.R Pilot project 3YPP	200K tagged items Automated inbound outbound in the DC Brand protection App consumer Samples' inventory On going
C	3 months	P.R Test Phase	Internal warehouse optimization pilot. On going
D	6 months	P.R Test Phase	Production process monitored QC optimization
E	1 year	Pilot project 1YPP	Production process monitored.

After the examination of these cases, the following features were evidenced:

- A strong personalization was required for each application depending on both business requirements and company's features.

- Each deployment necessitated both a detailed mapping of the AS IS processes and a test phase.

- Each implementation demanded different levels of system integration.

- The very different product categories in scope brought to deploy strong customized implementations.

- The external support for the analysis of technical issues and business process played an important role on the adoption of RFID.

Table 2.b: Critical issues

Company	Most critical issues
A	Unique tag required for all product categories: Tag position on item, tag dimensions. Read rate requirement for specific roller conveyor's speed value.
B	Management of two tags: association step needed. Two tags only for some categories. System integration fine-tuning.
C	Tag dimensions. Read rate requirement for specific roller conveyor's speed value.
D	Aggressive treatments required a high-resistance tag.
E	Management of tag encoding, matching the EAN barcode label

Other relevant aspects and critical issues were identified:

- The introduction of an RFID tag must not affect the quality and the visual merchandising standards of the product: if the tag is embedded on the product its thickness should guarantee its invisibility, while if its placed on the hangtag it should respect a pre-defined layout. One company removes the RFID hangtag due to the layout and dimensions in order to keep the retail layout but renouncing to the advantages in store operations.

- Some of the trade-offs adopted for the final solutions limit the benefits or future RFID uses in other processes: one case showed that guaranteeing the use of a unique tag type for all categories by placing the tag on the product packaging excluded the use of RFID in store where the product packaging is wasted.

- A noticeable reticence to RFID adoption was caused by the limited coverage of RFID consumer applications: many customers of the luxury segment are iOS users in which the Near Field Communication (NFC) reader was disabled for tag readings. This issue will be avoided soon due to the enabling of the NFC reader in the next version of iOS (11).

- Managing more than one tag for product implies greater efforts in terms of data management, processes, costs, etc.

- Some manufacturing processes may comprise aggressive treatments or procedures which can affect the tag integrity.

- The great and dynamic portfolio of products that fashion companies propose each collection may contain RFID hostile materials.

- The luxury segment has a special interest to protect the brands through RFID.

- Decisional processes were more or less fluent impacting on the project planning.

- The test phases included finished high-value luxury products, this implied special attention by the operators during their manipulation and transportation.

- Embedding an RFID tag on the products requires more attention to security and privacy concerns.

- Training sessions reduced the reticence to new technologies and showed essential for the success of the RFID adoption.

A framework to facilitate the implementation of RFID in the fashion supply chain is proposed in the next section. The consideration of the features and critical issues evidenced in the last two sections might orient adopters during the decision making for RFID applications outlining and deployments.

4. Framework

Equipping a product with a tag enables the company to collect specific data about the product through RFID systems, in order to achieve different goals, as examined in the cases of study. The flow chart of the proposed framework is showed in Figure 1.

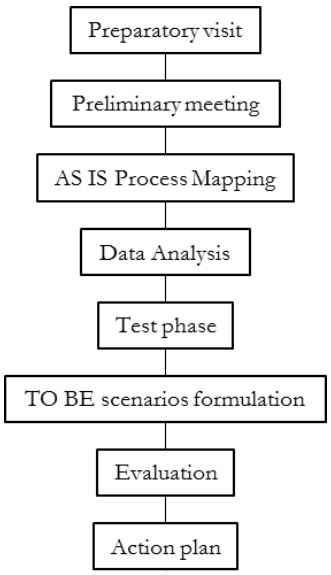

Figure 1: Proposed framework

The implementation of RFID technology often requires a substantial revision of logistics and supply chain processes. As a result, a feasibility study must analyze the processes in

their current scenario (AS IS), and then proceed to their redesign, evaluating both technical and managerial feasibility of the re-engineered solution.

The proposed framework starts with a preparatory visit to the environments where both RFID equipment and tagged items will be handled. This visit will provide further details about the processes and about the environment in order to determine the macro characteristics of the RFID readers needed, future RFID areas and distances to avoid interferences and evaluate the operability of RFID within the specific environment.

Afterwards, during a preliminary meeting and while keeping in mind the issues evidenced in the previous sections and the main goals of the RFID deployment, the following aspects should be analyzed:

- The interested processes' context

- Product categories in scope

- Tag placement preferences

- Type and number of tags needed to achieve the pre-established goals

- Type and number of devices (reader/printer)

- Software interfaces, required data, level of integration

- Perimeter and test volumes (number of items per box, package size)

- Target performance values

- Security and privacy issues, clauses of confidentiality

- Exception management

The next step is the AS IS Process Mapping, which is vital for the formal definition of business processes because it allows management to assess almost at a glance any bottlenecks, inefficiencies or critical issues of the process. To optimize the analysis, usually conducted through field visits and interviews, it is important that the project team's stakeholders possess adequate knowledge of the studied process. Therefore, the AS IS Process Mapping shall collect all the qualitative (objects and subjects) and quantitative (volume and timing object) information for each of the processes undergoing study (selected depending on the strategic purposes of the project).

The analysis of the collected data will evidence the critical issues that are intended to be reduced or eliminated by accomplishing the project goals previously defined. The analysis should include physical flows, data flows and managerial flows. Furthermore, it is necessary to quantify the goods' flows related to the processes under study. This analysis provides key information in order to conduct a more realistic test phase: quantity of products contained in a typical box or pallet, positioning of the products in the packaging, etc.

At this point evaluating the performances of RFID technology through a test phase will be crucial. The tests should be conducted by following the specifications found during the earlier phases. Antennas' positioning, reading rates, identification of hostile products, tag positioning, are some of the aspects that need to be considered in this step.

Finally, one or more re-engineered TO BE scenarios will be formulated: the previously identified processes will be redefined in order to achieve the pre-established goals. Each scenario must contain precise decisions concerning technology, data and management (devices, system integration, activities and new procedures, etc).

In order to define the scenario to be implemented, the project team will evaluate, qualitatively and quantitatively, the developed solutions.

Solutions should also contain economic considerations comparing emerging costs due to implementation of the new RFID technology (hardware and software issues) with savings that can be achieved when optimizing company's SC processes. As widely discuss within literature such savings can arise from achieving higher inventory accuracy, reducing manual labor (as in case study A where company was moving from a traditional manual warehouse to an automatic one), collecting real time data both during the production processes as well as at the retail level (Sell In).

Lastly, a communication and training campaign should be conducted in order to obtain users and stakeholders' acceptance and commitment thus reducing exceptions.

5. Conclusions

The main purpose of this paper has been to analyze the deployment of RFID in the fashion industry. The overtaking improvements that this technology can provide are still not completely exploited by the fashion companies: there is a considerable awareness about the benefits and some of them already deployed RFID for a specific process, but just one of the studied companies is oriented to integrate transversely the use of RFID technology.

The literature was reviewed and some cases of study were analyzed in an effort to structure a framework to support an effective implementation of RFID in the fashion supply chain. As far as a strong personalization is necessary due to business process requirements and features of each application, the definition of a "one-size-fits-all" approach is not possible. As a result, the proposed framework provides general guidelines in order to evidence and assess the specific features of each scenario and, thus, facilitate the formulation of a tailored solution for the implementation of RFID.

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