RFId-enabled Lateral Trans-shipments in the Fashion & Apparel Supply Chain

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Abstract. There is a growing attention towards the application of Radio Frequency Identification (RFId) technology in the Fashion & Apparel supply chain. This paper describes a Lateral Trans-shipment replenishment policy enabled by item-level RFId tagging. In fact, in order to adopt a Lateral Trans-shipment policy, a firm should have an accurate visibility of both the inventory level in its warehouses and in each store. Such visibility can be provided by RFId technology. An analytical model has been developed to evaluate the convenience of applying a Lateral Trans-shipment policy, and the main managerial implications are discussed.

1 Introduction

There is a growing interest in the application of Radio Frequency Identification (RFId) technology in the Fashion & Apparel industry, proved by the various projects launched worldwide (e.g. [1]). Both managers and academics foresee that RFId can lead to great benefits in terms of reduction of thefts and counterfeiting, increment of on-shelf availability, and thus a better service level (e.g. [2]). In fact, RFId enables the monitoring of WIP (Work In Progress) and finished products along the supply chain, thus allowing a better control of the process [3]. Moreover, this better visibility enables new replenishment policies like Lateral Trans-shipment, i.e. the shipment of goods between two retail stores, which are believed to lead to a reduction in stock-outs, inventories and transportation costs [4].

The relationship between RFId technologies and new replenishment policies aimed at improving the performance in the points of sale is little studied in the literature, with a few notable exceptions (e.g. [5]). This paper aims to present an analytical model to assess the benefits of RFId-enabled Lateral Trans-shipment policies in the Fashion & Apparel industry.

The paper is structured as follows. Section 2 presents the problem context, underlining the effects of Trans-shipment policies and the RFId technological scenario required to perform such policies. Section 3 provides the description of the analytical model and Section 4 presents the results of its application to a prominent Italian company. The last section presents a discussion and some concluding remarks.

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2 Context

2.1 Lateral Trans-shipment in the Fashion & Apparel Supply Chain

In the Fashion & Apparel Supply Chain the points of sale are usually replenished from local distribution centers or warehouses. The products are shipped with a "Less than Truck Load" transportation, i.e. small trucks or lorries visit many stores in a round trip. Nevertheless, when the distance between the warehouse and the points of sale is not that small, if a store runs out of an article, it can take a very long time before that product is replenished from the warehouse. If consumers cannot find a product on the shelf, the company owning the stores suffers a lost sale.

The Lateral Trans-shipment policy can be used to avoid product shortages or to reduce the effects of shortages, i.e. the time during which the product is not available. Lateral Trans-shipment means a "horizontal" shipment between two nodes at the same level of a supply chain, in our case two stores [4], [6]. This means that the store which runs out of an article can be supplied by another store (owned by the same company) which still has enough quantity of the same article. More specifically, Lateral Trans-shipments can be divided into Emergency Lateral Trans-shipments (ELT) and Pre-emptive Lateral Trans-shipments (PLT). ELT is the reaction to a stock-out occurring in a store, and consists of providing the store with the required articles from another store that has ample stock [7]. PLT instead reduces stock-out risk by redistributing the stock between the stores before customer demand is realized [4], [6].

Lateral Trans-shipment policies could be very useful for firms operating in the Fashion & Apparel industry since:

- The configuration of the Fashion & Apparel supply chain includes many stores located very near to each other (e.g. in the city center) with a central warehouse usually located far from them;
- The demand characterizing the products of this industry is hardly predictable (fashion effect);
- The stores usually keep small amounts of stock due to the scarce availability of space, again as they are usually located in the city center.

Currently, firms operating in the Fashion & Apparel industry do not have an accurate visibility of the inventories, especially those available in the stores. This inaccuracy is due to thefts and shrinkage (e.g. shipping errors) occurring in the supply chain between the Central Warehouse and the points of sale. Moreover, thefts and errors can also occur inside the points of sale. The lack of visibility is an obstacle to the implementation of Lateral Trans-shipment, as this policy requires knowledge of the exact level of inventory in each store. The inaccuracy could be eliminated by scanning all the articles at their arrival to the point of sale, thus updating the inventory status. Nevertheless this operation would take too much time if performed with traditional bar-code technology. In fact, it would require to open each case, remove the plastic bag that covers each article, find the bar-code and scan it. RFId technology, thanks to the possibility of identifying the articles without a direct line of sight, can provide an extremely efficient and effective way of performing this activity.

2.2 RFId Scenario

RFId technology allows the tracking of every single article along the Fashion & Apparel supply chain. A unique identifier (EPC, Electronic Product Code) can be written in the tag applied to each article, and the specific product features, along with supply chain information (e.g. the countries where the product is designed or produced), can be associated to each identifier in the firm's Information System.

Using RFId scanners, the operators can identify all the goods without opening the cases, by simply waving the scanner near each case. When the operators read the tags, the new location (i.e. the store) is recorded in the Information Systems. The technological feasibility of this solution has been proved by the tests carried out by the Italian GS1 EPC Lab, which has shown good read rates [8]. More specifically, three reading configurations have been tested to better simulate different application scenarios: clothes contained in a box moved on a conveyor, hanging clothes moved on a roll-container, and multiple boxes of clothes moved on a roll container.

Two tagging solutions can be adopted.

1. Apply a re-usable tag that can be removed by the operators when the product is sold and then sent back to the plant to be put on other products. These tags should be designed in order to prevent the damage of the articles (cf. Figure 1a). They might have also anti-theft functionalities. As a drawback, they are quite expensive and unwieldy.
2. Apply a disposable tag whose removal from the article is not required when sold. This tag can be integrated in the article label, thus supporting anti-counterfeiting and, potentially, anti-theft functionalities. This tag is less expensive than the former and, because of its small dimension, there is no risk to damage the articles (cf. Figure 1b).

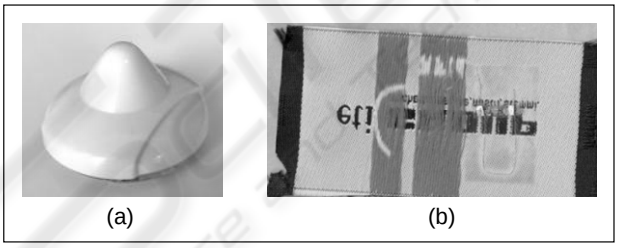

Fig. 1. The RFId tags (courtesy of the Italian GS1 EPC Lab).

2.3 Reference Replenishment Policies

When a stock-out occurs in a store (called Receiver Store), without the adoption of RFId technology, the store manager can decide to:

1. "*do nothing*" (DN), i.e. the store manager decides to bear the cost of stock-out without changing the replenishment policy. The basic assumption is that if the customer does not find the article in the store, the sale is lost unless the article becomes available in a few days (which is not possible without changing the replenishment policy);

2. adopt a "*Central Warehouse - Express Courier*" or CWEC policy, i.e. the use of Express Courier services for an emergency shipment from the Central Warehouse. The basic assumption, as described later (cf. Section 3), is that the customer accepts to come back to the point of sale to buy the article if it is made available at the store in a few days.

When the RFId scenario described in Section 2.2 is adopted, a third option is available:

3. adopt an "*Emergency Lateral Trans-shipment*" or ELT policy, i.e. an urgent shipment from another retail store (called Supplier Store) of the same company. Again, the basic assumption is that the customer is willing to wait a few days in order to buy the article. When a stock-out occurs in a point of sale, the store manager contacts an Express Courier to transport the needed product from the Supplier Store to the Receiver Store. This policy can be applied only if the firm has a complete, accurate visibility of stock in all the points of sale, which is the case if item-level RFId tagging is adopted.

3 Model

The proposed model aims to evaluate the benefits related to the adoption of a Lateral Trans-shipment policy which is enabled by RFId technology. In order to do this, the model compares the payoffs of the three replenishment policies described in Section 2.3 (DN, CWEC, ELT). These payoffs have been evaluated by considering a base-line situation in which the article is available at the store and can be sold.

The model has been developed under the following assumptions.

- The model supports the management of a stock-out that has already occurred, while it does not take into consideration policies which can be adopted to prevent future stock-outs.
- When a stock-out occurs in a store, there is at least one product available in the Central Warehouse and one product available in an other store.
- When a stock-out occurs, the customer is willing to wait a few days in order to buy it. This "fast delivery" is enabled only by the CWEC and ELT policies, while the replenishment time in the "do nothing" scenario is too long. More specifically, when a CWEC or an ELT policy is adopted, the customer is supposed to book the missing article and buy it when it becomes available at the store.
- When a Central Warehouse Express Courier (CWEC) or an Emergency Lateral Trans-shipment (ELT) policy is adopted, the cost to process the additional shipment order is considered to be negligible.
- The model refers to a scenario in which only one article at a time runs out of stock, while it does not consider the situation in which many articles are simultaneously out of stock.

The model is based on the following parameters.

1. *Price (PR)*, i.e. the price of a single article.
2. *Gross Margin (%GM)*, i.e. the difference between the price and the production cost of a single article, expressed in percentage of the price. The value of %GM has been assessed through a real case and is 42.2%.

3. *Consumption probability (PROB)*, i.e. the probability that a product is bought in a store. *PROB* depends on various factors, the most important being the current level of stock in the store and the remaining time before the end of the season. These factors are not explicitly considered in the model, but they should be considered to assess the proper *PROB* value.
4. *Expected Markdown (%EM)*, i.e. the percentage of expected reduction of the price of an article. The *%EM* should be higher when the product is expected to be sold near the end of the season or in the end-of-season sale. The expected value of %EM has been assessed through a real case and is 7.8%. This value already takes into account the probability of selling a product with different discount prices and the discount prices themselves.
5. *Transport Cost (TC)*, i.e. the cost of transporting the goods from one destination to another. The model considers only the extra-costs to transport the missing goods to the store urgently. This cost is usually high, as the transport is performed with an Express Courier. We refer to TC_{ELT} in case of Lateral Trans-shipment from a nearby store and TC_{CWEC} in case of Central Warehouse Express Courier case. The value of TC_{ELT} is € 10; the value of TC_{CWEC} is € 15 if the Central Warehouse is located in the same country of the store and it is € 69 if the Central Warehouse is not located in the same country of the store.

It is now possible to compute the payoff for each identified policy. As stated before, the payoffs have been assessed by considering the differential costs and benefits with respect to the situation in which the article is available in the store. If the store manager decides to "do nothing" (DN), he tells the customer that the product is not available in the store. Obviously, the payoff of this policy is always negative, as the firm bears the stock-out cost without any additional income. The stock-out cost can be simply expressed as a lost margin (%GM*PR), as shown in Formula 1.

$$P_{DN} = - \%GM*PR \quad (1)$$

If the store manager decides to apply a Central Warehouse Express Courier (CWEC) policy, he will allow the customer to book the product, that will be shipped as soon as possible from the Central Warehouse through an Express Courier. Then, the payoff of the CWEC policy considers only the transportation cost through an Express Courier service from the central warehouse to the Receiver Store (TC_{CWEC}), since the article is indeed sold to the customer (cf. Formula 2).

$$P_{CWEC} = - TC_{CWEC} \quad (2)$$

If RFId technology is in place, the store manager might also decide to apply the Emergency Lateral Trans-shipment (ELT) policy. In this case the store manager will allow the customer to book the product, which will be shipped as soon as possible from a Supplier Store through an Express Courier. Then, the payoff of the ELT policy is the transportation cost through an Express Courier service from a nearby store TC_{ELT}. Moreover, it is necessary to consider that the same article, if not shipped to the Receiver Store, could be sold in the Supplier Store in the future with a probability *PROB*. For this reason, the expected value of stock-out cost in the Supplier Store should be considered (*PROB**%GM*PR), reduced by the entity of the Expected Markdown.

$$P_{ELT} = -TC_{ELT} - PROB*\%GM*PR*(1-\%EM) \quad (3)$$

4 Results

This section presents the results obtained by the application of the model to a reference multi-store fashion company (Table 1).

Table 1. Payoffs for the different policies.

Article price PR (€)	***PROB***	**Payoffs (€)**			
		DN	CWEC		ELT
			Same country	Nearby country	
30	~0	- 12.66	- 15.00	- 56.34	-10.00
	0.25				-12.92
	0.5				- 15.84
	0.75				- 18.76
	1				- 21.68
60	~0	- 25.32			- 10.00
	0.25				- 15.84
	0.5				- 21.68
	0.75				- 27.52
	1				- 33.36
120	~0	- 50.64			- 10.00
	0.25				- 21.68
	0.5				- 33.36
	0.75				- 45.04
	1				- 56.72

In particular, the three replenishment policies have been compared for three levels of article prices: "Low price" (€30), "Average price" (€60) and "High price" (€120). Moreover, since the results depend on the probability that a product is sold, five different values of *PROB* have been considered.

Obviously, all the payoffs are negative, since the base-line scenario is the absence of stock-outs and the considered options are ways to mitigate the effect of a stock-out. The results depicted in Table 1 show that:

- The payoffs of the DN policy depend on the price of the article (the higher the price, the higher the stock-out cost) and are not affected by the probability *PROB*.
- The payoffs of the CWEC policy depend only on the location of the central warehouse. If the Central Warehouse is located in a nearby country, the transportation costs are significantly higher.
- The lower the probability *PROB*, the higher (i.e. the less negative) the payoffs of the ELT policy, because the firm succeeds in exploiting the highest margin from products that have already been shipped to the stores and that can have little likelihood of being sold in the future.

Analyzing the results, there is strong evidence that the Emergency Lateral Transshipment enabled by RFId technology is highly recommended in a large number of cases. In order to support the decision, Fig. 2 compares the policies that can be adopted with or without the RFId technology on the basis of the location of the central

warehouse, the price of the article and the e the probability *PROB* of selling the article in the Supplier Store by the end of the season.

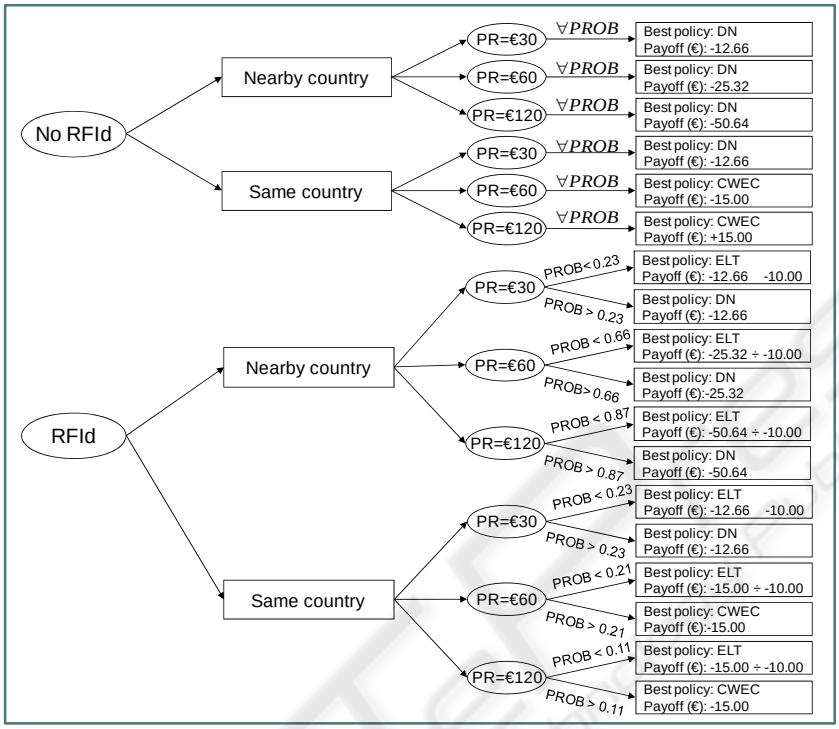

Fig. 2. Comparison of the different policies.

It can be observed that the payoffs obtained in the RFId scenario are always equal or higher than those obtained without RFId. This is due to the fact that RFId can enable a new policy (ELT) which proves to be convenient in most of the considered situations. Analyzing the results more in detail it can be observed that:

- When RFId technology is not implemented, the firm can decide to “do nothing” (DN) or to send the article from the Central Warehouse with an Express Courier (CWEC). A CWEC policy should be preferred when the additional transportation costs are covered by the additional margin, i.e. when the Central Warehouse is located in the same country or for high value products, and for “average” or “high value” products.
- In the RFId scenario, the firm can decide to “do nothing” (DN) or to adopt two alternative policies, i.e. CWEC or ELT. Figure 3 shows that when the Central Warehouse is located in a nearby country ELT becomes more convenient for high value products and for products which have little likelihood of being sold in future. In the other situations, the DN policy should be preferred due to the high transportation cost related to the CWEC policy. When the Central Warehouse is located in the same country and the article has a low probability to be sold ELT proves to be the best policy. In the other scenarios, DN should be preferred for

low value articles, while the adoption of CWEC policy is recommended for "average" or "high value" products.

5 Concluding Remarks

RFId technologies can enable an Emergency Lateral Trans-shipment (ELT) policy in the Fashion & Apparel Supply Chain. ELT is convenient when there is a low probability to sell the products at full price in the Supplier Store, therefore every potential sale should be exploited and when the Central Warehouse is far from the stores, e.g. it is located in another country, and an express shipment from the warehouse to the store would be extremely expensive.

Further studies should also investigate the Preventive Lateral Trans-shipment policy and relax some of the model assumptions, for instance considering a distribution network with more than two points of sale and/or a cost to process the additional shipment order different from zero. Further studies should also be devoted to the assessment of the benefits and the Return of Investment (ROI) ensuing from the adoption of item level RFId tagging in Fashion-Retail supply chain. This application, by improving visibility, can enable companies to apply a large set of different policies in terms of collaboration and replenishment, and not exclusively the Lateral Trans-shipment based ones.

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