RFID & Analytics Driving Agility in Apparel Supply Chain

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Summary: This capstone focuses on how RFID creates value in the traditional mass apparel supply chain by improving agility. Based on our sponsor's RFID pilot, we perform several analyses to identify relevant value drivers in the logistics & distribution and retail stages. The result shows that RFID substantially improves retail store KPIs. Furthermore, other stakeholders can leverage RFID data and perform advanced analytics, driving value creation.

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KEY INSIGHTS

1. **RFID enables end-to-end visibility that is beneficial to all supply chain stakeholders for different value drivers.**
2. **For speed and flexibility, there are various levers for different stakeholders.**
3. **Retail store stands to gain the maximum value from increased visibility, speed and flexibility. However, others can capture substantial value through data sharing.**

Introduction

The apparel industry, and retail in general, is in turbulent times. Today's consumers have less patience to wait, and omnichannel retailing is the new norm. This requires the entire apparel supply chain to be more agile, which means that stakeholders need to have better visibility, speed, and flexibility. While supply chain digitalization helps the industry to become more agile, enabling technology like Radio Frequency Identification (RFID) has not been adopted at scale. Pilot successes varied, and a wide range of limitations and perceived limitations continued hinder RFID's proliferation. Historically, cost would also have been an inhibitor. As the technology continues to mature, its limitations reduce, and its price point is now at a level where it can be dispersed at the item level relatively inexpensively. This means that wider adoption is now feasible, and there is renewed industry interest in exploring RFID's value creation potential for the apparel supply chain.

This capstone's sponsor is a leading apparel and consumer goods sourcing company that provides end-to-end supply chain and logistics solutions for brands and retailers. With a network of thousands of suppliers and factories across the globe, the sponsor is keen to explore ways to increase agility for itself and its partners. In this context, it initiated a pilot to understand how RFID creates value for stakeholders and increases agility within its ecosystem. While there are numerous well-documented RFID benefits in all four apparel manufacturing stages: design, production, logistics & distribution and retail, this project focuses on the last two stages based on the sponsor's pilot.

In this project we have evaluated that in the traditional mass apparel industry, how can RFID create value by improving agility through increased visibility, speed and flexibility?

Methodology

We approached the research question through the lens of the sponsor's ecosystem, as illustrated in figure 1. First, we conducted structured interviews with business stakeholders to understand their pain points and perceived RFID value potential. Then, we studied the organizational processes for the context. Based on the interviews, we captured qualitative support that

RFID improves agility in all stages of the sponsor's apparel supply chain. Next, we quantitatively validated how inventory visibility and data insights captured during the RFID pilot help to improve agility in the logistics & distribution and store stages.

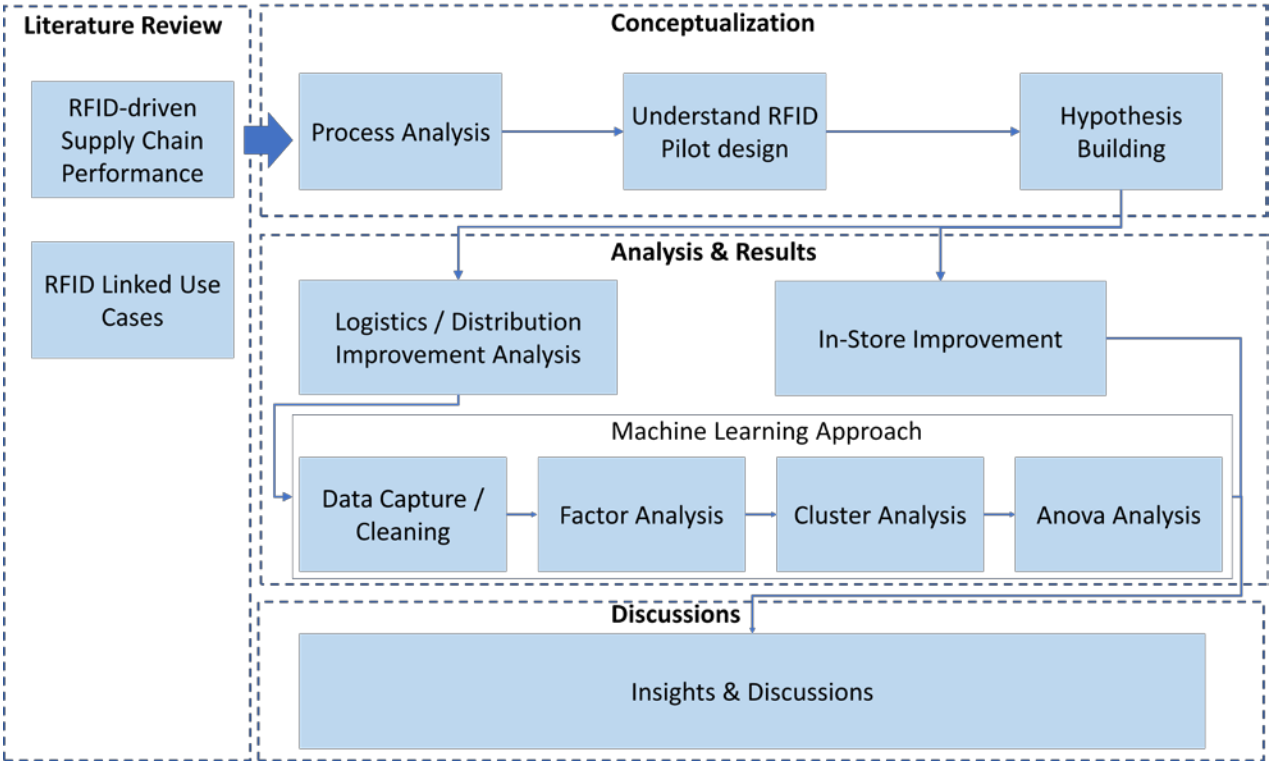

Figure 1: Capstone project flow

We plan to validate two hypotheses:

- H1. Logistics & Distribution: Advanced analytics using the machine learning approach will help to identify the right supply chain execution policies that improve the overall agility.

- H2. Retail: RFID implementation in store can significantly improve the overall performance. Increased visibility will enable better flexibility in meeting consumer requirements both in the retail and online channels.

To validate H1, we conducted a cluster analysis. We started the analysis with data exploration and cleaning. Initially, we had 6023 observations with 50 features. Next, we performed data preparation and dimensionality reduction. We one-hot encoded the categorical features and preprocessed data with z-score standardization. Also, we performed a correlation analysis to reduce collinearity. Then, we conducted the exploratory factor analysis (EFA) to group the features into easier-to-interpret factors. With EFA, we reduced the dimension of our dataset into four factors: volume, variability, sales channel, and product attribute. Finally, we transformed our data with the new factors and performed the k-means cluster analysis.

Our analysis yielded three clusters. Using the ANOVA test, we confirmed that the clusters are statistically significant ($p < 0.001$). We also performed a post-hoc Tukey test and validated that all four factors are different between the clusters. Using machine learning techniques, we found clusters with distinctive characteristics. Combined with RFID data, our sponsor can create targeted policies to improve agility.

To validate H2, we analyzed data from our sponsor's RFID pilot. The retail use cases centered around store on-shelf and inventory management. During the pilot, our sponsor identified multiple store KPIs that can be improved such as store shelf replenishment, out-of-stock SKU management, and misplaced merchandise management. RFID data brings out significant benefits in store operations in terms of increased visibility, high availability of item-on-shelf, increased inventory accuracy, and reduced effort.

Results

Using cluster analysis, we obtained three clusters as explained below.

Cluster 1 is the **fast moving omnichannel** cluster. Products in this cluster are of low to moderate price range and are sold through multiple channels. The fulfillment speed in this cluster is often impacted by system inventory inaccuracy. Currently, most of the sponsor's products are shipped from a centralized distribution center (DC), but there is a potential for

faster fulfillment through planned shipments from the nearest store. It is possible to employ an advanced algorithm to decide where to fulfill orders from, provided that the daily inventory record inaccuracy can be reduced using RFID.

Cluster 2 is the **online longtail**. There is anecdotal evidence that the order-to-delivery lead times for these products are high. In addition, products are currently offered online only when they are available in the DC, which can be few weeks after initial factory shipments. This
cluster's sales performance can be increased through the combination of early product exposure and reduced order fulfillment lead times, which RFID can support.

Cluster 3 is the **retail longtail**. These products are often from previous seasons or have higher initial allocated inventory. While our sponsor's inventory allocation algorithm considers historical sales data, it lacks the ability to use real-time product movement data captured by RFID. With additional insights, RFID can help to improve inventory allocation and balancing policies for the SKUs in this cluster, thereby improving flexibility.

In the retail environment, our sponsor currently performs bi-monthly physical stock take, and the inventory inaccuracy builds up over time. Based on anecdotal evidence, the inventory accuracy is approximately 95% in the stores. With proper implementation, the accuracy of detailed RFID-enabled inventory count can reach up to 99%, which is a significant improvement. During the pilot, the system inventory accuracy was around 96%. In general, the inventory accuracy increases immediately following stock takes, but it slowly degrades over time. In a cluster-wise inventory accuracy comparison using data from one store, we found that the rate of inventory accuracy degradation differs between the clusters as shown in Figure 2. For the fast moving omnichannel cluster, which is characterized by high volume and high product returns, the accuracy declines faster than the other clusters. Insight like this is where RFID creates value,

Figure 2: Cluster-wise inventory accuracy

as it plays a significant role in reducing the daily inventory record inaccuracies (IRI).
On-shelf availability is another area where RFID adds value. In our sponsor's retail stores, regular checks are expected to ensure that the required number of sizes for each style-color combination is always available. RFID helps to increase on-shelf availability through managing avoidable stock-outs, and as the result, sales volume can potentially improve 4-5%. Also, we found no significant difference cluster-wise for the on-shelf availability. This highlights that RFID in general can provide value by increasing product exposure for all clusters, thus improving sales speed.

Finally, we observed that the omnichannel fail rate can be reduced by as much as 10% using RFID. In our sponsor's context, fail rate is defined as the time lost from not finding the SKU in the assigned store. Because of sub-optimal system inventory accuracy, the fulfillment of online order from store becomes quite challenging, resulting in delays and lost sales.

Discussion

In general, RFID provides end-to-end product visibility which is beneficial for all supply chain stakeholders. It also improves supply chain performance by enabling more granular KPIs. For speed and flexibility, there are different levers for different stakeholders.

Examples of speed levers are:

- Manufacturing: Reduced lead time between product inspection and shipments.
- Transportation: A multi-stage joint replenishment and delivery model which facilitates optimal routing and reduced shipment lead time.
- Warehouse: Omnichannel order fulfillment time by identifying optimal shipping locations and reducing fail rate.
- Store: Time spent in locating items, replenishing stock, and managing returns.

Examples of flexibility levers are:

- Manufacturing: Right mix as per demand signals.
- Transportation: Proper stock redistribution.
- Warehouse: Ability to offer products wherever and whenever customers want.
- Store: Flexibility to adjust product mix according to customer demand signals.

Figure 3 is the summary of relevant value drivers for our sponsor and its partners based on our discussion with the stakeholders, literature review, and analysis. According to the literature and our observation, the retail store stands to gain the maximum value from increased visibility, speed and flexibility. Nevertheless,

significant value can be created for other stakeholders as well through transparency and collaboration.

RFID Enabled Initiatives	Value for Different Stakeholder											
	Manufacturing			Transportation			Warehouse			Store		
	Visibility	Speed	Flexibility	Visibility	Speed	Flexibility	Visibility	Speed	Flexibility	Visibility	Speed	Flexibility
Forecasting and Planning	●	●	●	◔	○	○	◕	○	○	●	●	●
Inventory Management	◔	◔	◔	◕	◕	◕	●	●	◕	●	●	●
Stock Replenishment	◕	◕	◕	◕	◕	◕	●	●	●	◕	◕	◕
Improve Shelf Availability & Exposure	◔	◔	◔	◔	◔	◔	◔	◔	◔	●	●	●

Figure 3: Value potential for different stakeholders

Conclusion

In this capstone, we validated that RFID indeed creates value for all apparel manufacturing stages through qualitative and quantitative approaches. Within the scope of the sponsor's pilot, we showed that significant improvements in retail store can be achieved through increased inventory visibility and exposure. In the logistics & distribution stage, we demonstrated that advanced analytics using the machine learning approach, combined with additional data points from RFID, can help to form supply chain execution policies that improve the overall supply chain agility.

Our research was limited by data, and data that span over multiple years would have generated insights with less bias and higher confidence, which our sponsor should consider for future research. In addition, combined with the right questions and the additional supply chain checkpoints, our sponsor or future researchers can conduct experiments that will quantitatively demonstrate RFID's value creation across all stages of the apparel supply chain between multiple stakeholders.