RFID Impact in Supply Chain: Innovation in Demand Planning and Customer Fulfillment

by

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Abstract

This thesis discusses the vertical relationship between vendors and retailers in both the barcode and Radio Frequency Identification (RFID) enabled environments. Its purpose is to find best practice in demand planning and customer fulfillment for vendors to improve customer service and reduce cost. Interviews were used to collect the information about current processes. A model was built to simulate the customer demand and inventory record accuracy, and this tool was used to analyze the different processes of demand planning and customer fulfillment.

The results show that, in order to improve the shelf availability and reduce cost, suppliers may consider (1) using Point of Sale (POS) data as a demand driven signal to facilitate Vendor Managed Inventory (VMI) to store level, which eliminates the retailer ordering process, and (2) monitoring the store traffic and backroom inventory by periodically checking the POS data and the information collected at the backroom-in and backroom-out points. Comparing the in-store traffic in different data points can reduce the time of out-of-stock, and reduce the possibility that products are in the backroom but not on the shelf. Retailers might still need their distribution center (DC) to reduce the transportation cost, but the retailer DC should do more cross-docking activities rather than build up inventories for stores.

Retailers will receive immediate benefits from this process change. Suppliers, on the other hand, will also enjoy significant reduction in inventory and increased product availability at the store level. Increasing the replenishment frequency, reducing the overall lead-time, and collaborating on promotion plan will all have notable impacts on improving customer service level and reducing on hand inventory. The key of RFID implementation is to broaden the collaboration with retailers.

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Chapter 1  Introduction

What process changes can a Consumer Packaged Goods (CPG) company make in order to utilize Radio Frequency Identification (RFID) technology to improve customer service and reduce cost? This thesis proposes a process change in an RFID-enabled replenishment system. In addition, it gives an overview of RFID technology, analyzes the combination of different parameters in the replenishment process, and shows the best practice in current technology.

RFID is a powerful technology for automatically tracing and tracking objects. This technology has existed for decades and RFID tags have common applications such as cell phones, toll collection systems, and proximity security systems. However, only recently has RFID technology been tested in the operations of merchandise supply chain management.

*RFID Journal* has reported a number of RFID mandates since 2003. In June 2003, as one of the leading sponsors of the MIT Auto-ID Center, Wal-Mart announced that it expects its top 100 suppliers to be RFID complaint at the case and pallet level by January 1, 2005. In addition, the US Department of Defense (DoD) proposed a similar mandate shortly after Wal-Mart’s announcement. The Food and Drug Administration (FDA), meanwhile, stated in its report “Combating Counterfeit Drugs” that, by uniquely tracking and tracing products, RFID could be one possible solution to drug counterfeiting problems. Furthermore, in January and February 2004 respectively, Metro Group, a German retailer, and Target Corporation, a U.S. general merchandise retailer, issued RFID mandates to their suppliers. RFID technology will provide real-time tracking ability across the supply chain and give birth to the next generation of demand planning and inventory management.

The future of the real-time supply chain relies not only on technology development, but also on business process innovation in both retailers and manufacturers that establishes closer strategic relationships among supply chain partners. This thesis maps the customer fulfillment process to explore the current business process, and then outlines and presents a real-time supply chain model associating the Vendor’s DC, Retailer’s DC, and Retailer’s store backroom. The objective of this thesis is to propose a change in business processes to improve customer service and maximize
benefits from RFID implementation.

This thesis includes seven chapters. Chapter two provides a general overview of RFID technology. It discusses how RFID works and explains the difference between RFID and barcode systems. Chapter three reports the findings from a literature review on the value of information in supply chains, and summarizes the parameters that impact supply chain performance. Chapter four presents current retail replenishment processes, which were collected from interviews with retailers and vendors. Chapters five and six describe the approach used in this thesis and present the findings. Chapter six also discusses the different scenarios of RFID implementations and their impact on supply chain performance. The last chapter discusses the limitations of this thesis and describes the areas that need future research.
Chapter 2  RFID Technology

The concept of RFID was established during World War II with the development of transponders to identify friend or foe (IFF) aircraft. In order to understand how RFID works within the supply chain, we need to understand the RFID technology and the differences between barcode systems and RFID systems. This chapter provides some background information about RFID systems. This thesis only focuses on the Electronic Product Code (EPC) standard developed by The Auto-ID Center in 1999.

2.1 Introduction of RFID System

The basic components of the RFID system include RFID tags, readers, middleware, and Enterprise Applications. The RFID tag consists of a chip and an antenna. The chip and antenna together are also called an RFID transponder. There are two types of RFID tags. One type is “active” and has a powered chip that emits (continuously or on demand) its identity. The battery-supplied power of an active tag gives it a longer read range. Currently, the active tag costs several hundred dollars each and is not commonly used.

The other type is “passive” and consists of a microchip with a coiled antenna. The microchip stores a serial number, such as an Electronic Product Code (EPC), that identifies a product and may also store additional information. At the moment, this is the most common method of identifying commercial objects using RFID. Passive tags can apply to item, case, and pallet level. Considering the privacy issues that arose from item-level tagging, retailers and CPG manufacturers are now focused on testing RFID at the case and pallet level.

The RFID reader, which contains a chip/circuitry and an antenna, sends out electromagnetic waves that form a magnetic field. In using its antenna, a passive RFID tag draws power from the magnetic field and actives the microchip’s circuits. The chip then sends RF waves back to the reader, and the reader converts the new waves into digital data. The data then are passed on to
computers that can process and/or store them.

According to a definition in "EPC Tag Data Standards Version 1.1 Rev.1.24", RFID middleware is a new type of software that sits between the RFID reader and conventional middleware. Working together with conventional middleware, RFID middleware (or Savant middleware) facilitates communication between enterprise application systems and a variety of automatic identification devices, such as RFID readers and bar code scanners. A Savant is "middleware" software designed to process the streams of tag or sensor data (event data) coming from one or more reader devices. The Savant performs filtering, aggregation, and counting of tag data, reducing the volume of data prior to sending it to Enterprise Applications.

Since only an EPC code may be stored on an item's tag, computer systems need a way of matching the EPC to information about the item. The Object Name Service (ONS) provides a global lookup service to translate an EPC, which is collected from a tagged product, into an IP address defining where the information about the product is stored. The information could be stored either on the manufacturer's server or on the international EPC server. According to Sanjay Sarma, a co-founder of The Auto-ID Center, the ONS is an automated networking service similar to Domain Name Service (DNS) and built on top of the DNS framework. It acts as a "telephone book".

The standard used to exchange information in the EPC network is the Physical Markup Language (PML). It is a collection of common, standardized Extensible Markup Language (XML) vocabularies to represent and distribute information related to RFID tagged objects. The PML standardizes the content of messages exchanged within the EPC network.

Enterprise Applications then turn data collected by RFID into meaningful intelligence that enable effective decision-making hence increasing the value of RFID deployments. In addition, companies and software vendors need to identify relevant workflow and processes that can benefit from RFID and identify the specific RFID data that can benefit supply chain management solutions. Middleware and enterprise applications are very important components in RFID implementation, because companies have to reply on middleware and application software to manage the huge amount of data. The following Figure 2.1, provided by Dr. Gitanjali Swamy, presents the basic components of an RFID system.
For more information about suppliers of RFID middleware and enterprise applications please refer to attachment one and two at the end of this thesis. Attachment three provides information of the price of RFID tags.

### 2.2 Difference between Barcode and RFID

The barcode system is now the most widespread method used for identifying items in commercial environments. The barcode is a binary code comprising a field of bars and gaps arranged in a parallel configuration. The sequence, made up of wide and narrow bars and gaps, can be interpreted numerically and alphanumerically. It is read by optical laser scanning, i.e. by the different reflection of a laser beam from the black bars and white gaps.

The major differences between the RFID and barcode systems are (1) barcode systems require line-of-sight whereas RFID systems do not, and (2) barcodes only identify the manufacturer and product whereas RFID systems can identify unique items if tags are applied at item level.
Due to the privacy concerns raised by the RFID item-level tagging\(^1\), in this thesis, we only focus on the benefits from the first characteristic, which allows the automated information collection and decision-making in supply chain management.

**2.3 RFID Investments in Retail and CPG**

Significant changes have taken place in the merchandising industry since 2003. Some major retailers, such as Wal-Mart, Metro, and Target, have announced their RFID mandates, and some CPG companies have announced their RFID implementation plans. Some companies are more active than others. Here, we review the current situation of RFID implementations in the retail and CPG industries.

Active retailers include mass-merchandisers, such as Wal-Mart, Metro, Tesco, Home Depot, Costco, and Target, and fashion stores, such as Kaufhof, Benetton, The Gap, Prada, and Marks & Spencer. Active members in CPG include Gillette, Proctor & Gamble, Kraft, Unilever, Coca-Cola, and Johnson & Johnson. According to Margulius (2004), UPS, one of the biggest logistics companies, is also involved in RFID pilot testing. The US government departments, such as US Department of Defense (DoD) and Food and Drug Administration (FDA), announced their RFID requirements as well. The table provided in Attachment four provides some information about the RFID mandates.

It is necessary to separate the customers into two categories, one with Electronic Data Interchange (EDI) / web and one without EDI/web data exchange. In this thesis, we only focus on retailers and suppliers with EDI/web capabilities. In the current situation, data shared between retailers and CPG companies may include Point of Sale (POS), Inventory levels, DC withdrawals, and Sales Forecasts etc. The accuracy of information, such as inventory report, is a challenge for both retailers and vendors.

According to the interviews with managers in anonymous stores, the current accuracy of inventory

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\(^1\) Some end consumers are concerned that their personal information be collected without notifying them. For example, the hidden tags embedded in clothes can possibly help to identify the real-time location of the persons who wearing them.
report in retail stores is about 88~95%. Stores normally assume that they receive the right products as listed in their shipping bills. In addition, the store inventory in backroom is often based on the assumptions rather than on physical cycle counts. In retail stores, the improved inventory accuracy could be one of the most important benefits for RFID implementation at the case and pallet level.

2.4 Literature Review of RFID Benefits

Many articles mention RFID benefits, but most of them do not quantify the benefits. In the following literature review, we choose some white papers that describe the benefits of RFID and provide a quantitative analysis.

2.4.1 Improve productivity and save labor cost

The direct benefits from the automation are the improved efficiency and improved accuracy in material and goods handling. Subirana et al. (2003) quantifies the value of RFID technologies in improving efficiency and accuracy in the warehouse of a CPG company. Combining process mapping and financial modeling, the authors found clear benefits from RFID technology in reducing process times, and thus bring the benefits of increased productivity and reduced labor costs. This working paper is one of the first attempts to identify the benefits of RFID technologies.

Joshi (2000) uses a System Dynamics model to simulate a beer distribution network to determine the benefits of information visibility. The results show that information visibility and collaboration provide approximately 40 to 70% reductions in inventory costs alone.

2.4.2 Automatic shipping and receiving verification

Milne (2003) focuses on automating both the tracking and tracing of goods during shipment as well as automating the receiving-verification process to accelerate receiving. This will allow the receiving party to reconcile in real-time the difference between product orders and the actual

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2 For those who interested in the process-based approach, please check Research Paper MIT Sloan 4450-03. CCS 223. The detail information about this working paper lists in the reference section of this thesis.
goods received. It will also eliminate human-related incorrect or incomplete data entry into information systems.

Goyal (2003) identifies a framework for information exchange alongside material exchange using Savant-to-Savant communication. It suggests a framework for automating business processes, such as shipping and receiving. This paper also illustrates how an automated system can still function despite some of its vital components malfunctioning. In the event that parts of a system fail to operate, the system can still function by defaulting to alternative processes without human intervention.

2.4.2 RFID in Demand Planning

Datta (2003) suggests a new way of doing demand planning based on RFID data by using Object Data Dependent Vector Auto Regression and Generalized Auto Regressive Conditional Heteroskedasticity. However, the hidden assumption in the suggested regression model is that all the vectors, such as inventory level and customer service level, have linear relationships with end-customer demand. This assumption might not be true in supply chain management, and is very difficult to be approved.

2.4.2 RFID in Pharmaceutical

Bellman (2003) discusses how RFID technology and information infrastructure will change the management and distribution of pharmaceutical products within the health care industry, and enable item-level product traceability.

This paper suggests an approach that can be used to trace and track the information about the drugs. The approach is influenced by the extent to which drug manufacturers, carriers, wholesalers and pharmacies have the necessary hardware and computing ability to read and process EPC information. This approach provides a framework for a safe and secure RFID-enabled supply chain.

2.4.2 RFID Re-engineering Supply Chain
Process changes are necessary before RFID implementation. In the long-term, it is possible that Auto ID systems will enable a complete re-engineering of the supply chain by removing the constraints of today's supply chain structures. McFariane and Sheffi (2003) shows that widespread introduction of automated identification (Auto ID) applications creates opportunities to overhaul and improve tracking and tracing systems, process control, and inventory management.

The major benefit of RFID is the automation in information collection. A replenishment system that maximizes the value of the collected information would be a process model for RFID implementation. The next chapter reviews the literature about the value of information in supply chain management. The conclusion of the literature can help identify the important parameters in demand planning and customer fulfillment. We then use a different approach to test those parameters in a statistical model, and identify best-practice of replenishment processes that maximizes the value of the information.
Chapter 3  The Value of Information

This chapter reviews the literature concerning the value of information. RFID in the supply chain is valuable for capturing accurate information and it is necessary to adopt the appropriate business processes in order to derive value from the extra information. In order to understand how real-time information captured by RFID can benefit the replenishment process, we need to first understand the value of the information and the important parameters in the replenishment process. A number of theoretical papers discuss the value of information.

The following papers show how sharing demand information can improve the total supply chain performance by reducing inventory and increasing customer service level. Lee et al. (2000) suggests that when the demand variation is high, the information from retailers will bring more value to vendors. Bourland et al. (1996) shows that, with more accurate demand information, the supplier could reduce inventories and improve the reliability of its deliveries to its customer, which in turn reduces the retailer’s inventory. The study also finds that timely demand information improves customer service level.

Many papers discuss the impact of reducing lead-time. Lee et al. (2000) suggests that when the vendor reduces replenishment lead-times, retailers enjoy more cost deduction than vendors do. Cachon et al. (2000) finds that reducing lead-time can reduce total cost in the supply chain.

Waller et al. (1999) concludes that increasing the frequency of inventory review and replenishment triggering reduces supply chain costs. Frequent replenishment reduces the standard deviation of production. Lower standard deviation lowers inventories, improves delivery accuracy, and improves capacity utilization. Johanna et al. (2003) shows the value of visibility greatly depends on the vendors’ replenishment frequencies and the production planning cycle.

The bullwhip effect refers to the increase in variability as demand signals propagate upstream. Chen et al. (1996) and Chen et al. (1999) quantified the Bullwhip Effect in a simple supply chain model. The study used a mathematical approach to present the impact of forecasting, lead times
and information. The researchers noticed that the bullwhip effect decreases with the number of observations, and increases with the lead-time.

Some literature targets the value of inventory information sharing. Cachon et al. (2000) studies the value of sharing demand and inventory data and finds that if retailers share both the order and inventory information with vendors, the total supply chain cost can be reduced 2~3% on average compared with the cost when only demand information is shared. Automatic and accurate inventory information is one of the major advantages of RFID implementation. Ng et al. (2001), Hong-Minh et al. (2000), Cheung and Lee (2002), and Gavirneni (2002) all demonstrate that sharing inventory information can reduce the inventory holding cost of the whole supply chain. He et al. (2002) shows that information used in inventory control can reduce the total inventory cost significantly.

Other literature studies the extent to which retailers and vendors should share information. Information sharing requires investments in IT infrastructures. Wei and Krajewski (2000) and Lau et al. (2002a) found that the differences between information sharing with key customer accounts and information sharing with all customers are not significant, if the cost of information sharing is high. In other words, companies can focus on their key accounts if the IT investment is considerably high.

EDI and web-based data exchange is popular nowadays in North American, which makes information sharing much easier than before. By using the shared information, each supply chain entity can make better decisions on ordering, capacity allocation, and production/material planning so that the supply chain dynamics can be optimized.

When considering the global supply network, information sharing, however, may not be beneficial to some supply chain entities due to high adoption cost of joining the inter-organizational information system, unreliable and imprecise information, and different operational conditions of each firm. Some barriers such as expensive technology investment, personnel training and lack of mutual trust hamper small and medium sized enterprises. It is therefore very important to evaluate the strategic partners and analyze the cost and benefit before adopting the approach of information sharing and RFID technology.
In this chapter, we reviewed literature exploring the value of information. We learned that the important parameters in improving supply chain performance are: (1) sharing demand information, (2) reducing lead-time, (3) increasing inventory review and replenishment trigger frequency, (4) increasing the number of observations when forecasting and, (5) sharing inventory information. In a later chapter, we test those important parameters in different processes and find the best practice for demand planning and customer fulfillment.

The next chapter discusses the current replenishment systems that are used by some major retail and CPG companies.
Chapter 4 Current Demand Planning and Customer Fulfillment Models

Demand management is often the first step in supply chain planning and management. If the demand data a company collected is not accurate, all the subsequent steps the company takes in manufacturing and fulfillment will be off too. The problems in demand planning and customer fulfillment are significant for CPG companies today. Their consequences affect product availability, retailer economics, and shopper satisfaction. For retail and CPG companies, less out-of-stock, lower inventory, and a more organized warehouse are the target of demand planning and customer fulfillment.

Many new concepts are developed for this purpose. The idea is to pull product through the supply chain in response to actual orders, rather than stock product ahead of time and push it to the distributors and retailers who then hope they can sell it. However, in reality, not many companies realize that different processes can bring very different results in their supply chain performance.

In this chapter, we first review the current demand planning and customer fulfillment models for a CPG company, called "ABC"\(^3\). The products of ABC have a strong brand power and a loyalty customer base. In the following chapters, we will analyze which process is the best for ABC in RFID-enabled environment to improve its customer service level and get most benefit from the RFID implementation. We assume ABC is managing different replenishment systems for different category of retailers. ABC has different demand planning and customer fulfillment models, including Conventional Model, Vendor Managed Inventory (VMI) to DC Level, and VMI to Store Level\(^4\). Please find the detail of those replenishment models as following.

4.1 Conventional Model

The conventional Model refers to the business model that customer replenishment process is

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\(^3\) The information of this chapter was collected by interviewing different retailers and CPG companies. ABC presents a CPG company with strong branch power, but it is not necessary a real company.

\(^4\) Some times vendor managed inventory to store level is also called Co-managed Inventory.
triggered by retailers’ orders. In our analysis, we assume this retailer has many stores and one DC. Retailer stores forecast demand based on the actual sales, and then place store orders to the retailer DC. The retailer DC forecasts the DC demand, and places DC orders to ABC. ABC will then start the replenishment process in its DC to satisfy the orders from the retailer’s DC.

Based on the sales history, ABC makes its forecast according to the retailer’s orders, and then places orders to its plant according to the relevant cost and lead-time. Order management group and demand-planning group in corporate-level of ABC review the orders, as well as ABC’s inventory information, to finalize forecasts of customer demand. ABC’s DC will receive instructions from corporate every day to do customer fulfillment. This replenishment system is triggered by the real orders received from customer’s DC. According to the demand forecast, the supply-planning group in ABC will send production schedules weekly to ABC’s plants, and manage the replenishment from ABC’s plant to its DC.

Figure 4.1 in the next page is one of the examples of the conventional model used by a retailer in North American. In this process, the stores forecast store orders according to the updated store inventory and POS data. If the inventory in the store is enough, no action is taken. If the inventory in the store is lower than the reorder point, the enterprise system will send store orders to the corporate buyers in retailer.

Buyers in retailer corporate forecast retailer DC demand, and place orders to ABC based on the DC inventory and the orders from the stores. Once the buyers in retailer corporate receive the orders from the stores, they will first check whether the inventory in the retailer DC can satisfy the orders. If the retailer DC has enough inventories, stores orders will be shipped from the retailer DC to the stores that requiring replenishment. If retailer DC inventory is lower than the retailer DC reorder point, buyers will place an order to suppliers through EDI.

Once ABC receives this order from retailers, it will first check whether its DC has enough inventories to service this order. If yes, the products will be shipped to retailer DC or stores according to the instructions in the order. If ABC does not have enough inventories available, ABC then ships the available inventory and reduces the order quantity directly. The retailer is notified about the actual shipped quantity through the Advance Shipment Notification (ASN) sent by ABC
when the products are shipped.

According to our interviews with the retail and CPG companies, we find that the order deduction without informing the retailers is a common problem in current business model. Buyers have to check the orders placed manually and constantly to make sure that retailer DC can have enough inventories. This uncertainty increases the fear that retailer DCs will not have enough inventory to serve the stores. In return, buyers may place more orders than necessary. This problem can cause extra and unnecessary inventories for both retailers and suppliers.

If RFID technology is used at the case and pallet level in ABC’s DC, and if the ABC gives the buyers the visibility of their orders at real-time, the buyers can check anytime where the products are and how long it takes to receive the products. Unnecessary inventory caused by the fear of uncertain supply could be eliminated and customer service level can be improved.
Figure 4.1 Sample of Conventional Fulfillment Process

<Sample of Conventional Fulfillment Process>

- **Corporate Buyer**
  - History Sales Data
  - Corporate Forecast
  - Store Order
  - Inventory enough in DC? (Y/N)
  - Place Order to Vendor
  - PO Info (EDI 850)
  - Invoice
  - Invoice Matching
  - Payment

- **Retail DC**
  - Updated Retail DC Inventory
  - Ship SKUs to Store
  - Retail DC receiving

- **Store**
  - Updated Store Inventory
  - POS Data
  - Store Order Forecast
  - Inventory enough in Store? (Y/N)
  - Store Receiving

- **Vendor Corporate**
  - Inventory Enough for Order? (Y/N)
  - Reduce Order to Available Inventory
  - ASN (EDI 856)
  - Invoice (EDI 810)
  - Receive Payment

- **Vendor DC**
  - Updated DC Inventory
  - Ship Order to Retail Store or Retail DC

Information Flow →
Material Flow →

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4.2 Vendor Managed Inventory to DC Level

Vendor Managed Inventory (VMI) is a supply-chain initiative where the supplier is authorized to manage inventories of agreed-upon stock keeping units at retail locations, which means sellers maintain inventory they own on the buyers' premises. This helps to minimize the retailer's investment in inventory. Introduced by Kurt Solomon Associates in 1992, VMI is in an effort to involve suppliers in the process to improve in stocks, lead times, and order shipment accuracy by providing a direct view of customer activity. Additionally, VMI is intended to leverage the manufacturer’s capabilities to manage and improve warehouse replenishment for retailers with resulting improvements in sales revenue and inventory efficiencies.

The conventional model we described before causes the bullwhip effect in the supply chain because of the order processes. Bullwhip effect is a pervasive supply chain problem whereby order variability grows as demand signals propagate upstream. To remedy this problem and to obtain a smoother material flow, companies have started to develop replenishment methods that operate without orders. The VMI suppliers have the freedom of controlling the downstream replenishment decisions rather than filling orders.

In VMI to DC level, the vendor is given access to its customer’s DC inventory and demand information. The vendor monitors the customer’s DC inventory level and has the authority and responsibility to replenishment the customer’s DC stock according to jointly agreed inventory control principles and objectives. Exceptions are handled manually. This process is normally used for “staple” products, which are high penetration and high frequency products. According to Hill (1999), some companies have realized tremendous results, reporting 400% increases in inventory turns and return rates that drop by 75%. Kmart and Wal-Mart are the "poster" companies for VMI - the most obvious beneficiaries.

In a sample arrangement of VMI to DC level, two receiving areas could exist in a customer DC. One is the vendor-managed area where inventory is monitored and replenished by ABC. The

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5 This definition can be found in the webpage of Supply & Demand Chain Executive. http://www.isourceonline.com/research/glossary

6 Penetration – percentage of households that purchase the category
Frequency – average number of times per year category is purchased
products in this area are "staple" products that located in homogeneous pallets, with several weeks holding inventory. The other area is the distribution area that is controlled by the buyers in the retailer. The buyers in the retailer manage inventory according to the forecast. This arrangement is important for seasonal or unpredictable products. Retailers can order heterogeneous pallets, and products could be different for each layer in the pallet. Once needed, goods will be labeled and shipped to stores. In order to save transportation and inventory cost, retailers commonly use cross-docking to ship combined VMI and other products from retailer DC to stores.

VMI to DC level brings many benefits for both ABC and its retail customers. VMI allows the retailers and ABC sharing the demand information. In addition, since ABC is free to choose the timing of the replenishment shipments, it can further dampen demand peaks, for example, by delaying non-critical replenishments (Kaipia et al. 2002). ABC also has the flexibility to do replenishment in the combination that benefit ABC’s transportation and load management. Retailers will not have DC inventory because ABC owns the inventory in retailers’ DC. This format is currently used in some mass-merchandize retailers.

4.3 Vendor Managed Inventory to Store Level

Another format of VMI is that ABC receives point of sale (POS) data and handles the inventory management for retailer stores. Retailers and manufacturers will also collaborate to forecast promotions. Store level VMI is sometimes called Co-Managed Replenishment. Co-Managed Replenishment was first piloted at Wal-Mart in 1995 and has expanded to some of the larger retailers and trading partners.

VMI to store level offers the vendor the retailer’s POS information, sometimes called sell-through information, rather than its orders. In this process, stores will not place order to the retailer DC. Retail and CPG companies will use forecast orders or automatic generated orders as the replenishment signals. Vendors will forecast and complete store replenishment according to the POS data and the inventory information received from retailers. Vendor will also take the responsibility of the entire inventory across the supply network, until the products are sold in the stores. Companies have reported inventory reductions, improved customer service, and reduced obsolescence as the results of VMI adoption (Fraza, 1998; HolmstroÈm, 1998; Kaipia et al.,
2002).

Currently, VMI to store level is not as popular as VMI to DC level. This process requires that the vendor train internal resources for a specific retailer. In addition, technology constraints limited the automatically collaboration forecasts. This technique is only available by a few of the larger retailers and their strategic partners. In addition, standardization of processes, methods and results became an issue. To be most effective, the programs of VMI to store level and VMI to DC level depend on strong partnerships with active communication, information sharing, joint problem solving, and commitments to continued development.

One sample process of VMI to store level is showed in the following process mapping. In this process, ABC will receive the inventory and POS information from the retailer, and will manage the replenishment in retailer DC and store backroom on behalf of the retailer.

According to the interviews we had with retailers, we found that suppliers manage replenishment to store backroom is rare in current retail industry. The most common way is that suppliers manage the inventory of certain products in retailers’ DC, and retailers manage the replenishment to their stores by themselves.
Figure 4.2 Sample of Vendor Management Inventory Process
4.4 CPFR

Collaborative Planning, Forecasting, and Replenishment (CPFR) is an initiative among all participants in the supply chain intended to improve the relationship among them through jointly managed planning processes and shared information. CPFR began with a pilot program between Wal-Mart and Warner-Lambert, called CFAR: Collaborative Forecasting and Replenishment. In 1997, the Voluntary Inter-industry Commerce Standards (VICS) Association developed the CPFR Initiative. In 1998, VICS published the first CPFR Guidelines. Since then, a large number of partners have developed CPFR pilots. The CPFR process lays the basic foundations allowing additional n-Tier links in the Supply Chain that are incorporated in a many to many collaborative partnerships such as with transportation carriers and raw material providers.

The main goal of the CPFR process between two partners is the joint sales forecast for items that will be specially advertised and promoted in the near future. The sales forecasts should work for the store level because each store has their specific promotion activities and the store location has different impacts on the promotion activities as well. Most CPFR pilots have focused at the DC level and not at the stores, because many CPG manufacturers have not been able to realize the benefits of consumer demand visibility of store sales versus orders at the retailers DC.

Technology constraints, such as both partners must have powerful transaction systems, have prevented the development of collaborative forecasts as well. When RFID technology implemented to item level, accurate information can be collected automatically from each store. This will help companies to achieve CPFR more easily and efficiently. However, with the RFID in case and pallet level only, this benefit will be very limited.

The next chapter reviews the methodology used in this thesis.
Chapter 5  Methodology

5.1 Introduction

RFID technology cannot bring significant benefits by itself. In order to leverage the benefits of the additional information, companies must consider their own situations, and decide the changes in the business processes and the changes in their strategic relationships with business partners.

This thesis compares different processes in demand planning and customer replenishment, and uses Base Stock Model to quantify and show the benefits of information sharing. Periodic review is commonly used in the retailer and CPG environment according to the interviews conducted. The objective of this analysis is to point out what are the important parameters in the planning and replenishment process, and what kind of information is useful to reduce inventory levels and increase service level for both the CPG manufacturer and retailer.

First, current existing processes of demand planning and customer fulfillment are described. Using the simulated POS data, the inventory level and fill rate for different processes are calculated in the model. The result shows the important parameters need to consider when design the demand planning and replenishment process.

Second, the impact of different accuracy in inventory record is analyzed. In order to elaborating the benefit of RFID technology in demand planning and customer fulfillment, we assume that current inventory accuracy is 88%~95% in the store backroom, 95% in retailer DC, and 98% in ABC’s DC. In the model, the error in inventory record is assumed to be normal distributed.

Third, different RFID implementation scenarios are described and compared. With different data collecting points, manufacturers and retailers can get different information from the RFID system. Return on investment (ROI) models should be used to evaluate the cost and benefits before the

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7 This assumption is based on the interviews conducted with retailers and CPG companies. Those numbers may be higher or lower for specified retailers and CPG companies.
investment of RFID technology. For example, the retailer needs to consider whether it is necessary to install readers everywhere in the store. For manufacturers, they can find what kind of data would be necessary for them to improve customer service, to increase sales by reducing out-of-stock, and to reduce inventory cost. This paper will not focus on the ROI analysis because of limited information. However, if the relative information is available, it is very important to do this analysis when a company is considering implementing RFID system.

The information about the process is collected via interviewing personal at both retail and CPG companies. Chapter four describes the general process. In this chapter, we will analyze not only the different processes, but also the different parameters used in the processes. Recall from chapter three that the important parameters in improving supply chain performance are: (1) sharing demand information, (2) reducing lead-time, (3) increasing inventory review and replenishment trigger frequency, (4) increasing the number of observations when doing forecast, and (5) sharing inventory information. The detail numbers used in different processes will be given later in this chapter.

Once we identify the best process, we will use that process model to analyze the benefits of RFID implementation in different scenarios, focusing on the benefits that barcode system cannot provide and the benefits of tagging at the case and pallet level. RFID implementation includes several scenarios. By listing the benefits of different scenarios, this paper attempts to show what kind of data are useful for retailers and vendors if RFID data available at certain points.

5.2 Structure of the Model

Consider a three-echelon inventory system with ABC's DC, a retailer DC, and three stores (an arbitrary number). The material flow shows in Figure 5.1. Vendor DC (ABC DC) places orders to ABC plant. Information flows are different for different processes. Figure 5.2 shows a general information flow chart. All the end-consumer demand that cannot be fulfilled at the first time is assumed to be lost. All the orders from retailer to ABC are assumed to be backordered if the demand cannot be satisfied at the first time. In real life, without notification, the vendors may cancel orders that cannot be fulfilled at first request. After the retailers know that their orders can

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8 This is the information collected by interviews with retailers and CPG companies. Different companies may have different ways
only be partially fulfilled, they re-submit the orders for the missing items or place orders to other vendors. However, in order to simplify the model and get insight of the business problem, all the orders from retailers are assumed to be backordered in the ABC’s order handling system. Figure 5.1 shows the material flow in this system. Vendor DC refers to ABC’s DC and factory refers to ABC’s plant.

**Figure 5.1 Structure Used in the Model (Material Flow)**

In this model, transportation lead-times are fixed from ABC DC to retailer DC and from retailer DC to stores. For three stores, the transportation lead-times are different. Each store may have different demand but the mean and standard deviation used to generate random demand are identical for all stores.

Two different data sets are used to evaluate the result of different processes. One set of data assumes that the demand faced by the stores is a simple auto-correlated function. Coefficient 0.7 is used to generate demand. For the auto-correlated demand, let $D_t$ be demand at time $t$ and $D_{t-1}$ be the demand at time $t-1$, where $D_t = d + \rho D_{t-1} + \epsilon_t$ ($d > 0$, $-1 < \rho < 1$, and $\epsilon_t$ is the error term). $d$ is a constant number. $\epsilon_t$ is an Independent Identically Distributed (iid) normally distributed with mean zero and variance $\sigma^2$. $\rho$ is the coefficient effect. According to Lee et al. (1999), positive coefficient of SKU means that the brand of products can bring the positive utilities to the customers, reinforce their purchasing behavior, and make them repeating the purchasing. The coefficient 0.7 means the product used in this model presents a product with a strong brand.
power. Customers normally are satisfied after buying this product and they repeat choosing this product if it is available in the store. Another data set is random numbers with mean 100 and standard deviation 10. Assume that demands are independent in non-overlapping time intervals.

Base Stock Model and Moving Average Forecast are used in generate forecasts and orders, without order batch constrains. In this model, order lead-time is denoted as L; order review period is denoted as R, which means the orders will be reviewed and placed every R days. Replenishment is assumed to be triggered the same time as order placed. If orders placed on day t, the products will arrive at the end of day \( t + L \) and available to serve demand in day \( t + L + 1 \). The replenishment lead-time is a known constant for different process, and a replenishment order is always placed on a regular cycle. When \( R = 1 \), this means that the replenishment order is placed every day. Detail lead-time \( L \) and review period \( R \) will be shown in a table later. Stores will receive replenishments at time \( t = r + L, 2r + L, ... \) The same applies to retailer DC and vendor DC.

The reorder point is calculated by \((L + R)\mu + k\sigma\sqrt{(L + R)}\). \( \mu \) is the mean of the demand and \( \sigma \) is the standard deviation of the demand. \( k \) is the safety factor used in the system. In the basic analysis, we assume fill rate reach 99%~100%, which is the ideal customer service level in ABC. Orders will be placed on each ordering date. Order Quantity = Reorder Point + Forecasted Demand – On-hand Inventory – On-order inventory.

All the information is exchanged through the headquarters of the vendor and retailer. In the following, the description of processes will be simplified. We simply say “stores place orders to vendor DC (ABC DC)” for the following process: stores place orders to the retailer headquarter, and then the orders are sent to ABC headquarter. ABC headquarter then places orders to ABC DC. Figure 5.2 shows the information flow in this model, Vendor DC refers to ABC DC and factory refers to ABC plant. Vendor headquarter means ABC headquarter.
5.3 Processes Description

As previously mentioned, three stores, one retailer DC, and one ABC DC are used in this model to compare different replenishment processes. The following table provides the lead-time information of the different stores and DCs. If the order process is eliminated in one stage, the order review and replenishment period for that stage should equal to one. For example, if the retailer DC is only used as cross-docking facility and does not place orders, the R for retailer DC should change from four to one.

<table>
<thead>
<tr>
<th></th>
<th>Order Lead-time (L)</th>
<th>Order Review and replenishment Period (R)</th>
<th>Total Lead-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store 1</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Store 2</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Store 3</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Retailer DC</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Vendor DC</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

The lead-times used here are only an example. Different partners may have different lead-times.
Four different processes are compared in this model.

**Process 1: Conventional Process with Orders from Stores**

The conventional process means stores generate forecast based on the sales and in-store inventory level. Then the stores place orders to the retailer DC. The retailer DC forecasts DC demand according to the orders received from the stores. Based on the forecast and its inventory level, the retailer DC will then place orders to the vendor. The vendor will forecast based on the orders it receives from the retailer DC, and then places its orders to its plant.

**Process 2: Conventional Process with Internal POS Data used in Retailer DC**

In this conventional process, all the stores send their POS data rather than their replenishment orders to the retailer DC. The retailer DC forecasts DC demand based on the POS data and places retailer DC orders to the vendor. In this way, the processes of store forecasting and ordering are eliminated. The vendor DC then forecasts its demand and places orders to its plant.

In this process, the order review and replenishment period in all stores should equal to one, because the ordering process in stores is eliminated.

**Process 3: Vendor Managed Inventory (VMI) to DC Level**

In this model, VMI means the retailers share the retailer DC information with vendors. The stores forecast their demand based on the end-consumer demand, and place orders to the retailer DC. The orders that the retailer DC received from the stores are available for the vendor DC. The retailer DC will also let the vendor know the inventory level of the SKUs in the retailer DC, which managed by VMI. ABC then forecasts for the retailer to replenish the inventory in the retailer DC. ABC forecasts for its DC inventory and place orders to its plant. In this case, the inventory in retailer DC is owned by the vendor.

In this process model, the timer of order reviewing and replenishing in the retailer DC should equal to one, because the ordering process in the retailer DC is eliminated.
Process 4: VMI to Store Level

In this process model, ABC receives stores’ POS data and forecasts based on those data. No formal orders will be placed. This means both the forecast errors in the store level and the retailer DC level are eliminated. One assumption made here is that ABC ships all the products via the retailer DC, although it is possible for ABC to ship directly from its DC to the stores. In this scenario, the retailer DC does only cross-docking. This model also assumes no delays in cross-docking. As the result, the total transportation lead-time for the VMI scenario equals the sum of (1) the transportation lead-time from ABC DC to the retailer DC and (2) the transportation lead-time from retailer DC to different stores. In reality, the cross-docking in retailer DC may not be necessary if no cost advantages in transportation can be found. Cross-docking helps to reduce less than truck load shipping. Collaborate forecasting should be used in this business model for promotion activities. However, in order to simplify the problem, this benefits of collaborate promotion are not quantified in this analysis.

In this process, the period of order reviewing and replenishing in all the stores and the retailer DC should equal to one, because the ordering process in all the stores and the retailer DC is eliminated.

Sensitivity Analysis

In order to compare the performance and showing the important parameters in replenishment systems, we make the sensitivity analysis in the model. The sensitivity analysis include (1) reducing the review period, which equals to increasing inventory review and replenishment trigger frequency in this model, (2) reducing lead-time, and (3) increasing number of observations. Results of the analysis will be presented in next chapter.

The best practice proved in this analysis will be chosen as the framework of RFID-enabled demand planning and customer fulfillment. With shared information and the process that maximize the value of the information, we are able to propose an example in process change in the next chapter.
Chapter 6 Value of Process Change in RFID Implementation

In this chapter, the result of process comparing will be first presented to show the impact of different parameters in demand planning and customer fulfillment process. This is help to understand what process we should be focus on, and what kinds of data are important in improving the business performance. Based on the simulated result, a framework for RFID implementation is selected. This chapter also compares different scenarios in RFID implementation.

6.1 Best Practice in Replenishment Process

In order to compare the performance of different processes, let’s first assume that all the stores, retailer DC, and vendor DC should reach 99%~100% average fill rate, which help to prevent out of stock by using inventory buffer. This allows us to compare the on hand inventory level of different processes. Please refer to the previous chapter for the detail description of the different processes. Here, we repeat the name of the process and group the processes to show the different performances of different processes.

6.1.1 Compare Four Different Processes

Process 1-1 - Conventional Process with Orders from Stores
Process 2-1 - Conventional Process with Internal POS Data used in Retailer DC
Process 3-1 - Vendor Managed Inventory (VMI) to DC Level
Process 4-1 – VMI to Store Level
Figure 6.1 Average On-Hand Inventory Level for Four Different Processes

<table>
<thead>
<tr>
<th>Reduce on-hand inventory</th>
<th>SKU with Normal Distributed Demand</th>
<th>SKU with Coefficient Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vendor (Figure 6.2)</td>
<td>Retailer (Figure 6.3)</td>
</tr>
<tr>
<td>Process 1-1</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Conventional Process with Orders from Stores</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Process 2-1</td>
<td>9%</td>
<td>-47%</td>
</tr>
<tr>
<td>Conventional Process with Internal POS Data used in Retailer DC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 3-1</td>
<td>-15%</td>
<td>-67%</td>
</tr>
<tr>
<td>Vendor Managed Inventory (VMI) to DC Level</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Process 4-1</td>
<td>-32%</td>
<td>-93%</td>
</tr>
<tr>
<td>VMI to Store Level</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

The following Figures, 6.2, 6.3, 6.4, and 6.5, show the inventory levels of different processes at different time. If using process 1-1 as the base model, we see the retailer starts to gain significant benefits when it uses POS data as the demand trigger. However, the vendor’s inventory will increase in the process 2-1, when the retailer uses POS data as its internal demand trigger but the vendor does nothing. If VMI is used for demand replenishment, both the vendor and retailer can enjoy inventory reduction. The following figures show the detail inventory level at different time.

Figure 6.2 Vendor On-Hand Inventory Level (Normal Distributed Demand)
The vendor has the highest inventory level in Process 2-1 - Conventional Process with Internal POS Data used in Retailer DC, and the lowest inventory level in process 4-1, VMI to store level.

Figure 6.3 Retailer On-Hand Inventory Level (Normal Distributed Demand)

![Retailer On-Hand Inventory Level Graph](image)

The retailer has the highest inventory level in Process 1-1 - Conventional Process with Orders from Stores, and the lowest in Process 4-1 – VMI to store level. This retail enjoys inventory reduction when it uses POS data as store replenishment trigger. VMI helps the retailer reduce most of its inventory.

Figure 6.4 Vendor On-Hand Inventory Level (Coefficient Effect)

![Vendor On-Hand Inventory Level Graph](image)

The vendor has the highest inventory level in Process 2-1 - Conventional Process with Internal POS Data used in Retailer DC. The retailer uses the POS data as its store replenishment trigger but
still sends orders to the vendor as the vendor's replenishment trigger.

**Figure 6.5  Retailer On-Hand Inventory Level (Coefficient Effect)**

![Retailer On-Hand Inventory Level (Coefficient Effect)](image)

**Observation:**

This group compares the inventory levels of different processes with the same lead-time and order review period (replenishment frequency assumed to be the same as order review frequency).

Result for vendor: the VMI model helps the vendor reduce its inventory. VMI to store level is the best practice for the vendor to maintain the customer service level at 99%–100% while the same time reducing inventory more than 25%.

Result for retailer: eliminating the order processing by using POS data to do replenishment will improve retailer's inventory control significantly. Retailers can save more than 45% inventory already if they start to use POS data as replenishment trigger instead of store orders. Vendor Management Inventory will help retailer gain advantages because the inventory in retailer DC will owned by the vendor. The coefficient effect has impact on retailer's on-hand inventory level. Products with trend demand may require higher inventory level to maintain the same service level. This result could be more convincing if using the real demand information to test the processes.
Both the retailer and the vendor can gain benefit from the information sharing. Figure 6.1 shows that VMI model smoothes the inventory levels for both the retailer and the vendor, and the retailer gains more benefits from this arrangement. VMI to store level is the best practice based on this analysis.

6.1.2 Sensitivity Analysis 1: Increase Order Review and Replenishment Frequency

In this group comparison, we will use the previous processes but increase the frequency of order reviewing and replenishing in ABC. Please refer to Figure 5.3 for the detail numbers used in this scenario test.

Process 1-2 – Conventional Order Process: vendor reduce review period (from 5 to 1)
Process 2-2 – Conventional Order Process: vendor reduce review period (from 5 to 1)
Process 3-2 – VMI to DC Level: vendor reduce review period (from 5 to 1)
Process 4-2 – VMI to Store Level: vendor reduce review period (from 5 to 1)
Figure 6.6  Average On-Hand Inventory Level – Increase Replenishment Frequency

<table>
<thead>
<tr>
<th>Reduce on-hand inventory</th>
<th>SKU with Normal Distributed Demand</th>
<th>SKU with Coefficient Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>(positive % means inventory increase)</td>
<td>Vendor (Figure 6.2)</td>
<td>Retailer (Figure 6.3)</td>
</tr>
<tr>
<td>Process 1-1</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Conventional Process with Orders from Stores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 1-2</td>
<td>-39%</td>
<td>-5%</td>
</tr>
<tr>
<td>Conventional Order Process: vendor reduce review period (from 5 to 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 2-1</td>
<td>9%</td>
<td>-44%</td>
</tr>
<tr>
<td>Conventional Process with Internal POS Data used in Retailer DC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 2-2</td>
<td>-40%</td>
<td>-44%</td>
</tr>
<tr>
<td>Conventional Process with Internal POS Data used in Retailer DC: vendor reduce review period (from 5 to 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 3-1</td>
<td>-17%</td>
<td>-60%</td>
</tr>
<tr>
<td>Vendor Managed Inventory (VMI) to DC Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 3-2</td>
<td>-76%</td>
<td>-60%</td>
</tr>
<tr>
<td>VMI to DC Level: vendor reduce review period (from 5 to 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 4-1</td>
<td>-28%</td>
<td>-93%</td>
</tr>
<tr>
<td>VMI to Store Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process 4-2</td>
<td>-77%</td>
<td>-93%</td>
</tr>
<tr>
<td>VMI to Store Level: vendor reduce review period (from 5 to 1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Observation:**

From the average inventory levels shown in the Figure 6.6, we notice the following:

- Both the retailer and the vendor can reduce their inventory when they change from the conventional order process to VMI.
- Changing the VMI-to-DC level to VMI-to-store level can reduce the inventory of both the retailer and vendor.
- For SKU with coefficient effect, the retailer receives more benefits from VMI, comparing
to the conventional process.

- For SKU with coefficient effect, the vendor receives more benefits from VMI-to-store level, comparing to VMI-to-DC level. This means products with strong brand power can gain more benefits from VMI-to-store level.
- Reducing order review interval or increasing the frequency of customer fulfillment can reduce vendor’s inventory. For products with normal distributed demand, this change can notably reduce the vendor’s inventory level.
- If the retailer uses POS data as internal demand driven signal, the vendor should increase its frequency of order fulfillment and try to arrange VMI for the retailer because its inventory could possibly increase if it does nothing and maintains 99~100% customer fill rate.

Vendor’s inventory level is reduced more than 40% when the vendor frequently reviews the order and does the customer replenishment. The vendor gains significant benefits from increasing the frequency of replenishment and order reviewing. Different demand patterns have different impacts on the inventory levels, but this point is not clear at this moment. Detail analysis can be done if real demand information is available.

Based on this analysis, we can conclude that vendor management inventory to store level is the best practice in terms of the value of information sharing. ABC will receive much more benefit if it also increases the inventory review and replenishment frequency.

If the vendor is currently using conventional process to do the demand planning and customer fulfillment, we can see clear benefits for the vendor to change its business process to VMI, especially the VMI-to-store model. In reality, companies should build a business case first to check the implementation cost and relative benefits. For products with high value and strong brand power, VMI-to-Store can bring more benefits for the vendor to improve customer service and reduce inventory.

Another result shows in the model is that vendors and retailers can use less inventory to reach higher customer fill rate if they implement the VMI-to-store level. This is not difficult to
understand because the above table assumes that customer fill rate must reach 99~100%.

6.1.3 Sensitivity Analysis 2: Reduce Lead-time

This analysis is aimed to see the impact of reducing lead-time. The result shows that if the vendor reduces its supply lead-time for one day, the inventory level of VMI model will reduce 2~7%. However, the relationship between the reduce lead-time and reduce inventory cost shows not linear.

In this analysis, we can also find that reducing lead-time will have more benefit for conventional business model, comparing with VMI. This result is reasonable according to the bullwhip effect formula proved by Simchi-Levi (2003). According to the simplified formula, if demand information is centralized, the variance of the orders placed by a given stage of a supply chain is an increasing function of the lead-time. If the demand information is decentralized, the variance increases multiplicatively at each stage of the supply chain.

6.1.4 Sensitivity Analysis 3: Increase Observations

In this model, the benefits of increasing observation are not clear. The inventory level has almost no changes after increasing observation data points. However, we strongly suggest using real demand information testing this scenario because the demand data used in this analysis may not be able to present the real demand fluctuation.

Up to now, we understand that VMI-to-Store level appears to be the best process that vendor and retailer should use. The following analysis will show the benefits of RFID-enabled environment in a VMI-to-Store model.

From this chapter, we show that VMI to store level will bring notable benefits to both suppliers and customers. We also shows that increasing the frequency of inventory review and replenishment and reducing the lead-time will significantly improve the supply chain performance. We should also notice that this process improvement should be done before the RFID implementation. Now, the question is how RFID can bring extra benefits to this business model.
Different scenarios will be compared later in this chapter.

6.2 RFID Scenarios

As we mentioned in the chapter two, the major difference between RFID and barcode system is that RFID enabled the automation of material handling and decision-making. We also choose VMI to store level as the process model for all the RFID scenarios because we proved that VMI to store level is the best practice. This RFID-enabled process has several scenarios. POS data are available in all the RFID scenarios. In different scenarios, we assume products are tagged only at the case and pallet level, and the reading accuracy is 100%. Followings are different scenarios:

1. The vendor receives RFID data when the retailer DC receives products.
2. The vendor receives RFID data when the retailer DC receives and ships products. Assume the retailer DC only ship products to its stores.
3. The vendor received RFID data from the retailer DC and the stores when their backrooms receive the products.
4. The vendor received RFID data from the retailer DC and stores, including both in and out.
5. RFID tags are at item level and readers can read all the tags in the backroom and front store.

Figure 6.7 RFID Scenarios

The overall assumptions used in the analysis of RFID impact listed as following:
- RFID tags at the Case and Pallet Level
- Tagged at source (Manufacturing or Pack Center)
- All available RFID data are shared
- All product lines are tagged
- Reader accuracy 100%

The following table summaries the benefits for vendors to receive the extra information from retailers. As we discussed before, the retailer will receive significant benefits from sharing information. Vendor should consider more about how to use the extra information to improve customer service and reduce cost.

**Figure 6.8 Vendor Benefits with Extra Information**

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Extra Information available</th>
<th>vendor benefits from the extra information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RFID implementation in four walls</strong></td>
<td>Receiving confirmation from retailer DC; POS data</td>
<td>Eliminating discrepancy; reduce complaining</td>
</tr>
<tr>
<td>1. The vendor receives RFID data when retailer DC receives products.</td>
<td>Accurate inventory of retailer DC</td>
<td>Accurate retailer DC inventory management</td>
</tr>
<tr>
<td>2. The vendor receives RFID data when retailer DC receives and ships products. Assume retailer DC only ship products to its stores.</td>
<td>Receiving confirmation from retailer store</td>
<td>Preventing out-of-shelf based on estimated backroom inventory</td>
</tr>
<tr>
<td>3. The vendor receives RFID data from retailer DC and the stores when their backrooms receive the products.</td>
<td>Accurate inventory of store backroom</td>
<td>Preventing out-of-shelf based on accurate backroom inventory; reduce shrinkage</td>
</tr>
<tr>
<td>4. The vendor receives RFID data from retailer DC and stores, including both in and out.</td>
<td>Accurate inventory of shelf stock</td>
<td>Accurately manage out of shelf; prevent theft; improve promotion management; better manage perishable products</td>
</tr>
</tbody>
</table>
The benefits discussed here are general. In reality, the benefits should be different for different products. For example, RFID benefits will be much higher for products with a higher margin, with short life cycle, and in promotion.

### 6.3 Benefits of RFID-enabled Process

With the information shared between retailers and vendors, we already proved that VMI-to-Store level should be the best process to manage demand planning and customer fulfillment when information is available. Different RFID scenarios can bring different information. In the following analysis, we focus on the store level to see what value RFID technology will bring to the vendor and the retailer. We compare the stock out level in two scenarios: (1) no RFID tags on products, (2) RFID data are available from the backroom in and out points. One sample process is introduced in Figure 6.10. A shelf stock-out checking model is also built to analyze the difference of those two scenarios.

Because we only tag case and pallet level, some important assumptions are used in this model:

- When the store backroom receives products from the retailer DC or the vendor DC, there is no minimum order quantity constrains. This means that the minim order quantity could be as low as one unit if an order is placed.
- When the in-store employees arrange replenishment from the backroom to the store shelf, they cannot open two boxes at the same time. Only one box is allowed to be opened in backroom. This assumption limits the inventory inaccuracy to the minimum level, if the quantity of items in one carton is very small comparing with its daily demand.
- Assume the daily demand in a store is equally distributed and the time intervals between the data check points are identical, although unequal intervals may be more reasonable because different customer traffic in different time during a day.

In scenario one, the vendor can check the out-of-shelf situation in current barcode system by using POS data and store receiving data. Considering the transportation cost between retailer DC and retailer store, we assume that each store will receive products from their DC maximum once a day.
We need to define the following vectors in this model.

The following vectors need to be defined in advance by the retailer and the vendor. The following numbers are just an example.

- The maximum stock volume on shelf – \( SV_{\text{max}} \) \( (SV_{\text{max}} = 10) \)
- The minimum stock volume on shelf – \( SV_{\text{min}} \) \( (SV_{\text{min}} = 100) \)
- The maximum stock volume in backroom – \( BV_{\text{max}} \) \( (BV_{\text{max}} = 300) \)
- The minimum stock volume in backroom – \( BV_{\text{min}} \) \( (BV_{\text{min}} = 150) \)
- Frequency of the store employees do store-front replenishment – \( F \) \( (F=1,2,3...,8) \)

For each time point \( t \) \( (t=1,2,3,...,n) \), we can calculate the following numbers

- Begin inventory on shelf – \( \text{Beg}_{S_t} \)
- End inventory on shelf – \( \text{End}_{S_t} \)
- Quantity of replenishment from backroom to store – \( \text{Rec}_{S_t} \)
- Backroom receiving – \( \text{Rec}_{B_t} \)
- Begin inventory in backroom – \( \text{Beg}_{B_t} \)
- End inventory in backroom – \( \text{End}_{B_t} \)
- Lost of sales – \( \text{Lose}_{D_t} \)
- Shelf replenishment trigger – \( X \) \( (X \text{ is binary, } 1 \text{ means to replenish shelf, } 0 \text{ means not to}) \)
- Backroom replenishment trigger – \( Y \) \( (Y \text{ is binary, } 1 \text{ means to replenish backroom, } 0 \text{ means not to}) \)

Demand information should come from POS data. In this model, the demand information comes from simulation because no real demand information available.

- Sales between the previous time point and current time point – \( D_t \)
  \[ D_t = \text{daily demand} / F \]
  (Assume the mean of the daily demand is 100, the standard deviation is 10)

The following formula used in this model:

For shelf:
If \( t_0/F = \text{integer} \), \( t_0 \) is the beginning of a day. Then, \( \text{BegS}_t = \text{SVmax} \).

If \( t_0/F \) does not equal to an integer, \( t_0 \) is not the beginning of a day. Then, \( \text{BegS}_t = \text{EndS}_{t-1} + \text{RecS}_{t-1} \)

\( \text{EndS}_t = \text{BegS}_t - D_t \), if \( \text{BegS}_t - D_t \geq 0 \); otherwise \( \text{EngS}_t = 0 \)

\( \text{LoseD}_t = -(\text{BegS}_t - D_t) \), if \( \text{BegS}_t - D_t < 0 \); otherwise \( \text{LoseD}_t = 0 \)

If \( \text{EndS}_t \leq \text{SVmin} \), \( X = 1 \); otherwise \( X = 0 \)

\( \text{RecS}_t = (\text{SVmax} - \text{EndS}_t) \times X \)

For backroom:

If \( t_0/F = \text{integer} \), \( t_0 \) is the beginning of a day, \( \text{BegB}_t = \text{BVmax} \).

If \( t_0/F \) does not equal to an integer, \( t_0 \) is not the beginning of a day, \( \text{BegB}_t = \text{EndB}_{t-1} + \text{RecB}_{t-1} \)

\( \text{EndB}_t = \text{BegB}_t - \text{RecS}_t \), if \( \text{BegB}_t - \text{RecS}_t \geq 0 \); otherwise \( \text{EngB}_t = 0 \)

If \( \text{EndB}_t \leq \text{BVmin} \) and if \( t_0/F = \text{integer} \), \( Y = 1 \); otherwise \( Y = 0 \)

\( \text{RecB}_t = (\text{BVmax} - \text{EndB}_t) \times Y \)

According to the calculation in the model, the following chart shows the relationship between shelf stock out probability and in-store replenishment frequency for one SKU, given the stock volume for shelf and backroom already decided. We can see that arranging store replenishments three times a day will eliminate most of the stock out on shelf. This model could be used for any SKU to test what is the best replenish frequency.
If RFID implemented in store backroom, retailers and vendors will receive real-time and accurate information of the inventory in backroom. If RFID does not implemented, those two numbers can still be calculated. However, the calculated result might be different with the actual inventory, because of the inventory shrinkage, misplacing, and discrepancy. If the inventory in backroom is very tight, the inaccurate inventory record is easy to cause shelf out-of-stock because the store has less backup for uncertain demand.

In the model, simulated inventory accuracy is used to test the RFID benefits. If we assume the inventory accuracy in RFID-enabled environment is 100%, we can test how improved inventory record can help preventing out-of-stock. In this case, the tolerance of inventory accuracy is maximum one box of products. According to the interview with retailers, normally store employees move the cases out of the backroom when they do in-store replenishment. They return the case to the backroom if some products are still left in the box. Assume that only one open case can exist in the backroom, which is normally the case, vendor will have a very good sense about the accurate inventory. Of course, the variability depends on the store traffic of that SKU and depends on the package size of the SKU.

---

10 The RFID reading accuracy is less than 100% in current RFID pilot tests.
RFID can reduce the out-of-stock that is caused by inaccurate inventories in the backroom. In this situation, the inventories are actually not in the store although the record shows there are enough inventories. Because we only tag at the case and pallet level, the benefits from this extra information is very limited.

In the model, we receives the result that if the inventory accuracy improve 1%, RFID may help to reduce the out-of-stock 0.02–0.06%. This number may not provide too much information because the result should be different for different settings of the backroom inventory. If the buffer inventory in backroom is higher, then RFID is less benefit; if the buffer inventory in store is very lower, RFID helps the retailers and vendors better control the out of stock on shelf. In other words, RFID may help to reduce store backroom inventory, but this benefit is limited at case and pallet level, and this benefit is different for different products.

The time of stock out in stores can be reduced by using this suggested process. Inventory accuracy can be improved after RFID implementation. The improved inventory report helps to reduce the stock out on shelf but the benefits are not significant. This benefit is more notable for the products with short life cycle and promotion products as we mentioned before. On another hand, the accurate backroom information will help the store employee do in-store replenishment more efficiently and accurately. Without the inventory information in backroom, employees have to go to the backroom to check how many products still in there and which location the products are. With the RFID information about the products available, employees will be able to know immediately how many products are available in the backroom and handle exceptions efficiently. For retail and CPG companies, a pilot test in store backroom is strongly suggested before the RFID implementation. Pilot test helps them identify appropriate inventory policies in the store. The information collected from the testing can also be help for quantifying the benefits from RFID implementation.

The next chapter summarizes the findings of this thesis, lists the limitations in the analysis, and discusses the possible future research topics.
Figure 6.10 RFID-enabled VMI to Store Process

<table>
<thead>
<tr>
<th>Store Shelf</th>
<th>POS Data</th>
<th>Inventory on Shelf</th>
<th>Put products on shelf</th>
<th>Collect SKUs need to be replenished</th>
<th>Real Time Backroom Inventory</th>
<th>Store Receiving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store Backroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor Cooperator</td>
<td>History Sales Data</td>
<td>Forecast</td>
<td>Inventory enough on shelf?</td>
<td>Generate Replenish Signal to Store</td>
<td>Inventory enough in Backroom?</td>
<td>Generate Replenish Signal to DC</td>
</tr>
<tr>
<td>Retail DC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor DC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Information Flow → Material Flow
Chapter 7  Conclusion and Future Research

7.1 Summary

In the previous chapters, we reviewed the current status of RFID technology, the value of the information, and different processes of demand planning and customer fulfillment. We showed that the best business practice in demand planning and customer fulfillment is the VMI-to-Store model, which requires the demand and inventory information be shared between retailers and vendors. Vendors and retailers should complete this step before implementing RFID.

Sensitivity analysis in this thesis shows that increasing the replenishment frequency and reducing the lead-time of customer fulfillment can notably reduce the vendor’s inventory level and improve customer service. We mentioned in the literature review that increasing the demand observations in forecasting could improve the accuracy of demand planning and reduce bullwhip effect in supply chain, but we did not find the obvious benefits in our model.

We also discuss the benefits of RFID at the case and pallet level. For RFID case and pallet level tagging, the major benefit in the demand planning and customer fulfillment is to improve inventory accuracy. The benefits are limited if the tags are not at item level. For example, the improvement of demand planning in promotion activities cannot be realized if tags are not at item level. Without unique item-level tagging, vendors cannot separate the promotional items sold from the normal items.

This thesis shows the value of the information collected from the store backroom. Retailers and vendors should share more demand and inventory data if the information exchange infrastructure is ready. Vendors should also analyze the data to derive patterns from them. One example mentioned in this paper is to use the POS data and the inventory information in the store backroom to prevent the events of empty shelves.
7.2 Limitations and Future Research

This thesis focuses on the vertical process between the vendors and the retailers. Some topics, such as transportation management and discrepancy reconciling, are still left for further discussion.

This thesis makes assumptions about demand pattern because of the limited information available. We assume the demand is normally distributed or auto-correlated. In reality, promotions and holidays have significant impacts on the demand pattern. The real demand could be more variable than the data used in the analysis. It will be more convincing if companies use their real data to do a similar analysis. It is important to understand the impact of different demand patterns to the result. The benefits of RFID implementation may be different for products with different demand patterns. Companies should think about what products can get more benefits from the RFID implementation. RFID benefits for products with other patterns, such as seasonal products, short life cycle products, and products in promotion, are not studied yet.

This thesis assumes that retailers use moving average and order-up-to level techniques to manage the demand and inventory planning. Future studies can test different forecast and inventory techniques to see which method is the best in the RFID-enabled value chain.

Business is becoming more and more global. RFID-enabled value chains will eventually globalize. Now Auto-ID labs exist in six countries, including U.S., U.K., China, Japan, Australia, and Switzerland. The next step is to standardize data exchange and to develop business protocol in a global scope. Currently, we have EPC, ISO, and UID. UID refers to Unique Identification, which is used by US DoD to uniquely identify items it buys and owns. In order for RFID to be success, those standards should be synchronized and further research needs to be done to bring them together.

The benefits of RFID implementations in Third Party Logistics (3PL) companies are another area that needs to be further studied. 3PLs could be one of the enabling or inhibiting forces affecting how RFID-enabled business processes work on a global scale. Small and medium CPG companies will rely on them to comply with retailers’ RFID mandates. CPG companies may also leverage 3PL’s specialty in global logistics management.
RFID technologies are not stable yet. Many pilot tests are facing some technical challenges because of the limitation of RF waves. For example, product and packaging characteristics can have different impact on the transmission of RF waves. Metal and liquid are two of the difficult materials to deal with. How to improve the technology to make it reliable and cost-effective needs to be addressed in a short term.

Debates still exist on whether or when RFID tags should go for item level. Privacy concerns are the major barrier. Consumers are not willing to trade off their personal information unless they recognize their benefits from the item-level tagging. Retailers need to study how to improve customers’ shopping experiences when RFID tags are at item level.

The benefits of item tagging are not studied in this thesis. Comparing with barcode system, RFID at item-level tagging can benefit the perishable-product management in stores. The employees in stores could efficiently identify out-of-date products and remove them. RFID-enabled enterprise systems can automatically offer promotion or discount to the products that close to the expiration date. This reduces the shrinkage, increases the customer service level, and reduces the possibility of lost sales.

Current barcode system does not differentiate the normal SKUs and promotional SKUs, because retailers do not want to increase the number of SKUs. The SKUs on promotion use the same barcode number although the packages could be different. Retailers normally arrange promotion in a certain period. However, vendors cannot differentiate the normal one and promotional one in their system. If the discount is arranged for a certain batch, products with coupon and without coupon will appear in the stores at the same time. This certainly increases the complexity in supply chain. It is not difficult to find packages with coupons sitting together with products without coupons. Barcode system cannot tell the difference between them. If the normal SKU sold in the promoted price, vendor will sure lose revenue. Every day low price is a good strategy to reduce the impact of promotion and to make the product flow a pipeline.

Another situation found common in barcode system is that vendors use the same barcode number for garments with the same color but different size. It is very difficult for retailers to manage the
inventory correctly. Both retailers and vendors will possibly lose sales, because customer may not be able to find the products they want, whereas the same time, the stores think they have enough inventories.

In summary, RFID implementation at the case and pallet level has limited benefits in demand planning and customer fulfillment. Before implementing RFID, companies need to first check their current business process, and gain benefits from process improvement. VMI to store level is a good practice if demand and inventory information can be shared between retailers and vendors. Vendors can also gain significant benefits from reducing lead-time and increasing the frequency of inventory review and replenishment. Furthermore, retailers and vendors can still estimate shelf status in the front-store by using POS data and store receiving information.
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### Attachment 1  Providers of Middleware:

<table>
<thead>
<tr>
<th>Company Name</th>
<th>RFID Solutions Announced</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFIDWizard's</td>
<td>Tag Katcher middleware</td>
</tr>
<tr>
<td>CheckPoint</td>
<td>EPC Management Platform</td>
</tr>
<tr>
<td>ConnectTerra</td>
<td>RFTagWare</td>
</tr>
<tr>
<td>Cisco</td>
<td>Real Time Retail Solutions</td>
</tr>
<tr>
<td>DataBrokers</td>
<td>filter and aggregate data, incorporate business rules and task management</td>
</tr>
<tr>
<td>Defywire</td>
<td>Defywire Mobility Suite</td>
</tr>
<tr>
<td>DSI(Data Systems International)</td>
<td>dcLINK suite</td>
</tr>
<tr>
<td>GenuOne</td>
<td>TraceGuard</td>
</tr>
<tr>
<td>IBM</td>
<td>DB2 Information Integrator</td>
</tr>
<tr>
<td>Intermec</td>
<td>Intellitag RFID</td>
</tr>
<tr>
<td>Matrics</td>
<td>Matrics Visibility Manager</td>
</tr>
<tr>
<td>OATSystems</td>
<td>Senseware - first reader-independent RFID middleware</td>
</tr>
<tr>
<td>ShipcomWireless</td>
<td>CATAMRAN framework</td>
</tr>
<tr>
<td>SunMicrosystems</td>
<td>Savant-based middleware solution; SunOne integration platform</td>
</tr>
<tr>
<td>TIBCO</td>
<td>Adapter - join force with Alien</td>
</tr>
<tr>
<td>Verisign</td>
<td>Root Directory for EPCglobal Network</td>
</tr>
<tr>
<td>webMethods</td>
<td>webMethods RFID Starter Pack</td>
</tr>
<tr>
<td>RFCode</td>
<td>TAVIS middleware</td>
</tr>
<tr>
<td>Informatica</td>
<td>Informatica PowerCenter; Informatica PowerAnalyzer</td>
</tr>
<tr>
<td>Oracle</td>
<td>new generation of RFID-enabled WMS; RFID-enabled E-Business Suite applications; Sensor-Based Services (SBS); Compliance Assistance Package (CAP); Application Server 11i.10 (have extension to talk to readers)</td>
</tr>
<tr>
<td>SAP</td>
<td>SAP Auto-ID Infrastructure software; SAP Event Management software; SAP Enterprise Portal; SAP R/3</td>
</tr>
</tbody>
</table>
## Providers of Enterprise Applications

<table>
<thead>
<tr>
<th>Company Name</th>
<th>RFID Solutions Announced</th>
</tr>
</thead>
<tbody>
<tr>
<td>PeopleSoftware</td>
<td>PeopleSoft EnterpriseOne and PeopleSoft World(TM)</td>
</tr>
<tr>
<td>Provia</td>
<td>ViaWare WMS</td>
</tr>
<tr>
<td>RedPrairie</td>
<td>Partner with Xterprise; RFID Product Suite</td>
</tr>
<tr>
<td>AstonBusinessSolutions</td>
<td>Axapta WMS</td>
</tr>
<tr>
<td>GlobeRanger</td>
<td>iMotion wireless application platform.</td>
</tr>
<tr>
<td>HP</td>
<td>RFID tracking system - testing</td>
</tr>
<tr>
<td>i2Technologies</td>
<td>Master Data Management (MDM) and Performance Management modules and its Supply Chain Event Manager (SCEM).</td>
</tr>
<tr>
<td>MagicSoftwareEnterprises</td>
<td>iBOLT Integration Suite</td>
</tr>
<tr>
<td>ManhattanAssociates</td>
<td>RFID in a Box, is a bundled package of RFID technology from Alien Technology Corp; PkMS warehouse management system</td>
</tr>
<tr>
<td>Manuguistics</td>
<td>RFID-enabled demand and supply chain management solutions</td>
</tr>
<tr>
<td>Microsoft</td>
<td>partner with Aston Business Solutions; Axapta WMS</td>
</tr>
<tr>
<td>NCR</td>
<td>RFID Store Services</td>
</tr>
<tr>
<td>Patni</td>
<td>SmartVISION</td>
</tr>
<tr>
<td>Trenstar</td>
<td>RFID-enabled, pay-per-use model of mobile asset management; align with Matrics</td>
</tr>
<tr>
<td>Informatica</td>
<td>Informatica PowerCenter; Informatica PowerAnalyzer</td>
</tr>
<tr>
<td>Oracle</td>
<td>new generation of RFID-enabled WMS; RFID-enabled E-Business Suite applications; Sensor-Based Services (SBS); Compliance Assistance Package (CAP); Application Server 11i.10 (have extension to talk to readers)</td>
</tr>
<tr>
<td>SAP</td>
<td>SAP Auto-ID infrastructure software; SAP Event Management software; SAP Enterprise Portal; SAP R/3</td>
</tr>
</tbody>
</table>
Attachment 3  Price Forecast of RFID Tags

Price of tags is still a critical problem in implementing RFID. Tag costs are extremely important, Mike Dominy, senior analyst at the Yankee Group, reported that tags will represent approximately 50 percent of spending on EPC- (electronic product code) based RFID during the next several years. The first RFID tags off the block likely will come from such companies as Alien Technology and Matrics, both of which recently have cut their RFID-tag prices. Alien reportedly is cutting its read-only tag prices to 20 cents a tag for all orders over one million, while Matrics is charging 10-30 cents for orders of 10 million plus.

The usage volume of RFID tags will directly impact the tag cost. According to the cost model provided by MIT Auto-ID class in 2004, we can forecast the tag cost based on the forecast made by research The Freedonia Group, a Cleveland-based industrial market research firm. They recently found that U.S. demand for smart labels is projected to expand more than 14% annually through 2007, approaching 11 billion units or $460 million. The largest gains are expected in the RFID label segment where the market size will nearly triple each year.

The following shows the tag price forecast based on the cost model provide by Dr. Gitanjali Swamy, as well as the market research made by Freedonia Group. According to this forecast, 5 cents target could probably be reached by 2007.

Figure A-3 RFID Tag Price Forecast
## Attachment 4  RFID Mandates and Tests

<table>
<thead>
<tr>
<th>Retailer</th>
<th>suppliers involved</th>
<th>tag level</th>
<th>DC involved</th>
<th>Stores involved</th>
<th>deadline</th>
<th>tag</th>
<th>reader</th>
<th>Consulting and IT service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro</td>
<td>top 100 suppliers</td>
<td>case and pallet</td>
<td>10</td>
<td>281</td>
<td>Nov-04</td>
<td>Philips</td>
<td>Intermec</td>
<td>Cisco; SAP; IBM</td>
</tr>
<tr>
<td>Wal-Mart</td>
<td>top 100 suppliers</td>
<td>case and pallet</td>
<td>3</td>
<td>150</td>
<td>Jan-05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wal-Mart</td>
<td>all vendors</td>
<td>case and pallet</td>
<td>100</td>
<td>3000</td>
<td>Jan-06</td>
<td></td>
<td></td>
<td></td>
</tr>
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