Future impacts of RFID on e-supply chains in grocery retailing

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Abstract

Purpose – To place the research on radio frequency identification (RFID) usage in supply chains within a specific business and market context; in this case, the grocery industry.

Design/methodology/approach – This paper considers RFID research within the context of the grocery industry and outlines the market drivers that affect the way the grocery industry approaches RFID and also specific areas of research on RFID that should be undertaken to better provide the grocery industry with managerial insights into this technology's application.

Findings – Examining market drivers that are leading to RFID implementation in the grocery industry, this paper provides a theoretical framework for future applied research on RFID implementation. Specifically, it develops a research framework that includes research using modeling techniques, RFID implementation and the impact of RFID on daily operational issues.

Research limitations/implications – This paper focuses on the market drivers for RFID implementation. While it does address other areas that are related to research in this field, it is limited in its ability to go into detailed discussion of those areas. For example, while technology implementation and innovation diffusion issues are raised, they are detailed research domains of their own which can only be superficially addressed in the context of this paper.

Practical implications – The paper provides a detailed framework of research areas that are of direct, practical importance to the grocery industry. This should encourage research into this area, for, as researchers provide insights into these issues, the grocery industry can immediately put the findings into practice.

Originality/value – RFID has garnered a great deal of research interest. However, that research has primarily focused on RFID's impact on general supply chain issues, failing to place the discussion within a specific business domain. This is necessary because the strategic environment of any business impacts on the applicability of any technology.

Keywords Supply chain management, Communication technologies, Food industry, Retailing

Paper type Research paper

Introduction

Recently, Wal-Mart announced that they would require all of their larger suppliers to implement radio frequency identification (RFID) on every box and pallet shipped to Wal-Mart by 2005 (Boyle, 2003). Much like they did with EDI development, Wal-Mart is beginning to drive the adoption of RFID, which will mean significant changes in the way supply chains are managed. Other key players driving the development and adoption of RFID include the US Department of Defense, Proctor and Gamble, and the European retailer Metro Group (*RFID Journal*, 2004). However, just as EDI implementation differs depending on the industry, so will RFID since each industry has specific needs and requirements to meet their supply chain objectives.

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While research has been conducted on RFID, it has tended to focus on the specifics of the technology (Finkenzeller, 1999; Gould, 2000; Niemeyer and Pak, 2003) or its general promise of cost savings (Donovan, 2003; Kunii, 2003). What has been missing is a discussion of the market drivers (i.e. technology pull, or the forces that drive companies to adopt a technology or methodology) that lead various industries to consider RFID. An understanding of the market drivers of an industry is essential in order for practitioners to best implement a new technology, and for researchers to best understand what issues need to be addressed. The primary focus of this paper is to examine market drivers that are leading to RFID implementation in the grocery industry.

We focus on the grocery industry because it is a prime candidate for RFID implementation. Over the past decade, grocery retailers have acknowledged that their supply chains are not responsive enough. To deal with this, they have invested millions into new techniques such as automatic replenishment programs (ARPs). Unfortunately, grocery retailers have actually increased average inventory levels and their related costs (Stank and Crum, 1999; Bowersox and Closs, 1999; Brown and Bukovinsky, 2001). RFID provides the opportunity to reverse this trend and truly integrate the grocery supply chain.

This paper provides a theoretical framework for applying RF technology in grocery supply chains. It provides a

Supply Chain Management: An International Journal
Volume 10 · Number 2 · 2005 · 134–142

framework of supply chain management in the grocery industry, and outlines the major operational requirements that any new system must provide. It then discusses how grocery stores can utilize this technology to change the entire method in which they operate their supply chains. We then outline several distinct research streams to provide a framework for future applied research in this area.

Literature review

Automatic replenishment programs: failure to deliver

The main driver in recent grocery retailing research on supply chain issues is the program of efficient consumer response (ECR) that was initiated in the USA after a key report by Kurt Salmon Associates (1993). The motivation for this report was the declining profitability of the grocery industry in the face of competition with Wal-Mart and other warehouse clubs/superstores. The key finding in the report was that in the early 1990s the grocery supply chain was extremely inefficient. On average it took 104 days for dry grocery products to go from the supplier to the consumer. The main reason for the large amount of held stock was the fragmentation of the supply chain. Specifically, stock was pulled through the supply chain by way of replenishment orders for stores, but inventory was pushed through the warehouse system by trade promotions and forward buying practices. Forward buying emphasizes acquiring larger quantities of products based upon the purchase volumes necessary to get the best discounts from manufacturers. These quantities are stored in the warehouse. However, products are removed from the warehouse and sent to the stores based upon what the stores forecast they can actually sell. This difference, between acquired (pushed) volume at the warehouse and actual sold (pulled) amounts at the stores, causes substantial inventory growth within the warehouses of the supply chain.

Forward buying began in the 1970s as a way for manufacturers to use discounting to bypass the price controls implemented by the Nixon administration. Forward buying is a practice on the part of the buyers, who are stocking up, to take advantage of low price offers due to special promotions, quantity discounts, or special pricing discounts. However, in the 1980s, instead of phasing out these programs, they became more heavily used because consumers were hooked on discounting. In fact, grocery manufacturers' spending on trade promotions from 1981 to 1991 increased from 34 to 50 percent while advertising fell from 43 to 25 percent. Kurt Salmon Associates argued that this inefficiency, if removed, could save around $10 billion (10.8 percent of sales turnover) in the dry grocery chain. In general, the report held that ECR would reduce inventory levels to 61 days.

Kurt Salmon Associates argued that "by jointly focusing on the efficiency of the total grocery supply system, rather than the efficiency of individual components, they are reducing total system costs, inventories, and physical assets while improving the consumer's choice of high quality ... grocery products" (Kurt Salmon Associates, 1993). ECR is in the same family of programs as continuous replenishment planning (CRP) and vendor managed inventory (VMI). All these programs fall under the umbrella term of automatic replenishment programs (ARPs). The basic structure showing the reliance on reliable information can be seen in Figure 1.

In general, the goal of ARPs is that "the system must at any time provide sufficient supplies of goods in demand at the right spot and at competitive prices. These goods are standardized with a limited shelf life, with little opportunities for market segmentation and with a high demand for efficient logistics. Therefore, there has been a shift from pushing goods through the distribution network to a situation where the goods are pulled through the distribution network" (Ciborra, 1995). Thus, goods need to be replenished more frequently with a smaller average order size. This means that "the optimization of replenishment processes has been a focal strategic issue" (Damsgaard and Lyytinen, 2001). In short, the ultimate goal is that, "the right products reach the shelves at the right time and at lower cost and thus boost sales and profits" (Cottrill, 1997).

Since the Kurt Salmon Associates report was released, research has shown that many grocery firms have implemented ECR/ARP programs (Daugherty and Myers, 1999). Unfortunately, the results have not been as good as hoped. For example, inventory stockpiles have actually increased since 1992, along with their attendant costs (Stank and Crum, 1999; Brown and Bukovinsky, 2001). Bowersox and Closs (1999) studied nine retail grocery chains that had implemented ECR from 1992-1997. They found that the chains had decreased average inventory turns and increased inventory levels, but net profit margin increased 22 percent and ROA increased 7 percent. The report concluded that the improved profits came from larger volume purchases, which generate increased promotional money at the expense of lower operating efficiency. More recent research (Brown and Bukovinsky, 2001) also found that most ECR adopters' inventory efficiencies, asset efficiencies, and cash cycles generally deteriorated compared to non-adopters. Some have argued that ECR's promised savings are limited because retailers and manufacturers refuse to abandon forward buying practices (Partch, 2000). So, we see that the current use of technology is not providing the desired results, and we must look for other options. This is becoming a more pressing issue because market saturation is changing the basis of competition.

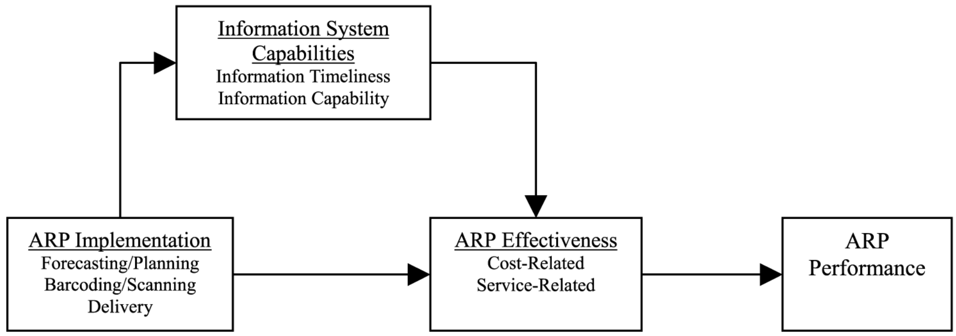
Market leakage and the need for increased product selection

During the 1990s grocery store chains grew both in size and in geographic location. On one hand, grocery retailers expanded into suburban and rural areas while the stores themselves grew in size. These expanded stores, called superstores and megamarts, provided shoppers with huge selections, but also with huge sizes (many are over 50,000 square feet). The reason for this growth in size was simple. Retailers had to compete more directly and "differentiate themselves from each other, destroying the consumer's commodity-like perception of competing stores" (Duke, 1991). This is a direct result of shoppers' desires. Table I shows that after convenience, shoppers choose a store based on product range/selection, which even exceeds the importance of price.

The reason for this can be explained through market leakage analysis (Ohme, 1982), a tool used to identify future directions for growth. Figure 2 shows the key components. There are two key market factors: a company's share of the market and the leaked market which the company could serve but doesn't. In the traditional market, a grocer would have its

Supply Chain Management: An International Journal
Volume 10 · Number 2 · 2005 · 134–142

Figure 1 A framework of automatic replenishment program relationships



Source: Daugherty and Myers (1999)

Table I Factors affecting shopper store choice

Factor	Percentage
Convenience	54
Product range/selection	14
Low price	13
Quality	9
Cleanliness	2
Friendly staff	1
Handy operating hours	1
Others	6

Source: A.C. Nielsen Company Ltd (1989)

own customers (section D). In addition, there would be market segments and customers they choose not to compete for (section E).

If they are to gain market share, they must win some of the leaked market while keeping their own customers. Market leakage occurs in three main forms. First, there are customers that were competed for but lost (section C). Second, there are also those customers who are not covered by the distribution channel (i.e. stores not in the area) which are represented by section B. Finally, customers in section A are lost because product models or brands they would like to buy are not offered.

In today's market a company's strategic choices are more limited. Specifically, section E (customers not competed for at all, such as product categories not carried) is a limited market since competition has grown more acute. Section B is also limited because grocery chains have now expanded into many, if not most market areas (i.e., market saturation). Thus, section A is the segment of the market that is most easily accessible to grocery stores, garnered by expanding the product/model variety carried in a product category. However, grocery stores have finite shelf space, and that shelf space typically is the only inventory storage available to the store. On one hand, they must keep enough product on hand to avoid stockouts, or they will lose more customers (section C). On the other hand, the only way to provide more products and model variety is to limit the amount of shelf space each individual product takes up in the store. If grocery store retailers are to be able to manage these varied demands, they must be able to identify product on an individual item level. Thus, one of the key theoretical questions is, to what extent can technology be utilized to reduce inventories, and therefore shelf space for individual products. This would allow a greater variety of products while maintaining high service levels.

Individual product identification and item level supply chain management

Item level identification must be the foundation for item level supply chain management. Item level identification, therefore, is only possible if each item has its own identity that can be recognized easily and efficiently within the entire supply chain. Wireless product identification has recently garnered the interest of researchers (Karkkainen and Holmstrom, 2002). The general technology can be viewed as a wireless barcode. Because of its flexibility, this technology provides the technical basis to manage individual items in a supply chain. Figure 3 illustrates the enabling factors this technology provides.

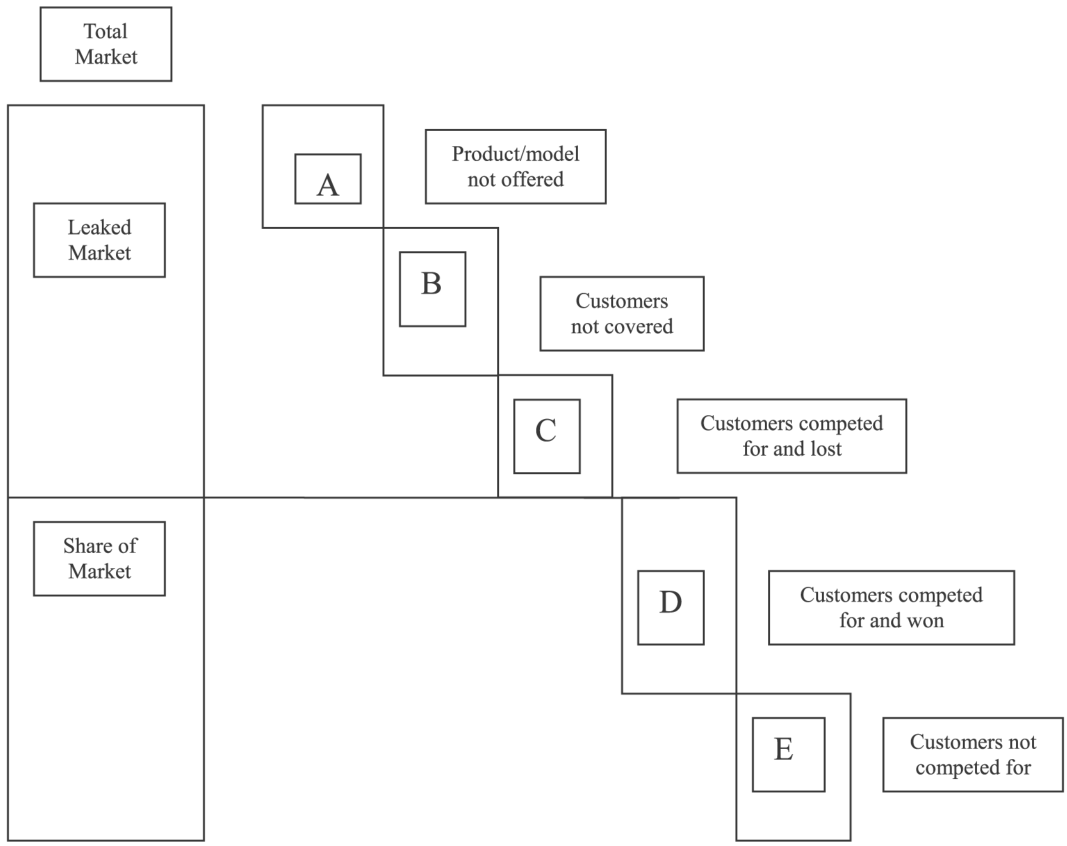
First and foremost, no physical contact is needed to interact with the product items, allowing for increased handling efficiencies. Bar-code readers are no longer needed to update inventories, and theoretically, even checkouts could be eliminated. Recent research reports that checkout costs account for approximately 3 percent of retail revenue in supermarkets in the industrialized world (Hennessy, 2000). Currently some supermarkets are experimenting with self-checkout capabilities. Wireless technologies using electronic payment methods could allow shoppers to walk out of the store without stopping at a checkout station, having their goods scanned automatically and their credit cards charged. This could lead to reducing (and possibly even eliminating) the entire process and cost of customer checkout (*Chain Store Age*, 1999).

Identification of item level products also allows effective customization of products. In e-grocery retailing, wireless product identification can allow new offerings to customers in addition to making it easier to assemble and deliver the order. In the physical store, since products can be identified remotely, inventory could be managed from the distribution center. These capabilities allow for true VMI (Smaros and Holmstrom, 2000).

Finally, this effective information sharing also allows for better control of the supply chain. When companies move from focusing on functional requirements to supply chain solutions, visibility of the supply chain increases and allows for

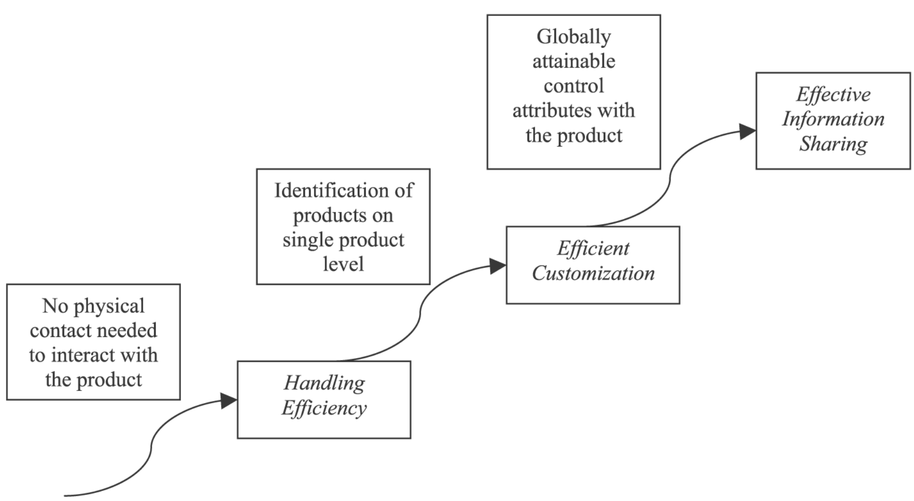
Supply Chain Management: An International Journal
Volume 10 · Number 2 · 2005 · 134–142

Figure 2 Market leakage analysis



Sources: Ohme (1982) and Duke (1991)

Figure 3 The enabling steps of item level supply chain management



Source: Taken from Karkkainen and Holmstrom (2002)

greater control and efficiencies. In the case of grocery stores, store inventory could be managed from the distribution center. This is something that many grocery supply chain managers have wanted for some time. In personal interviews for this research, managers from both Kroger (Carson, 2003) and Albertsons (Salmon, 2003) grocery store chains expressed their desires for the benefits that RF technologies can provide. Automating inventory replenishment decisions would result in significant cost savings to the stores, by freeing up time that department managers spend walking the floor

Supply Chain Management: An International Journal
Volume 10 · Number 2 · 2005 · 134–142

checking the shelves to see what is needed. The managers stated that this time would be better spent on in-store customer service activities (Carson, 2003; Salmon, 2003).

If the inventory is managed from the distribution center (DC), and updates are available in real-time, then stock-outs should be significantly reduced. According to one report, stock-out situations cause a 3 percent loss of revenue through lost sales, and 53 percent of the time, stockouts result from problems with the store ordering process (*Supermarket Business*, 1996). In comparison, only 8 percent of stockouts are caused from inventory being delivered, but not shelved.

Given the promising benefits of wireless product identification, we believe that RFID provides these benefits and that its costs are near the threshold to be widely used in the grocery industry.

RFID technology: background and explanation

RFID is a very compact technology. About as large as a pinhead, RFID tags (or simply RF tags) consist of two main components: an antenna and a chip that contains an electronic product code (EPC). The EPC standard was developed by the Auto-ID Center, a partnership founded in 1999 by five leading research universities (anchored by the Massachusetts Institute of Technology), and nearly 100 leading retailers, consumer products makers, and software companies (Niemeyer and Pak, 2003). RF tags can provide more information than traditional barcodes. For example, not only can an RF tag tell what the product is, but also when and where it was made, where its components came from, and when they might perish. Another benefit is that unlike bar codes, which need line-of-sight scanning to be read, RF tags also act as passive tracking devices, broadcasting a radio frequency when they pass within yards of a special scanner.

RFID technology is robust and has been used for some time in harsh manufacturing environments (Gould, 2000; Murray, 2003). Other applications include car toll tags and security-ID badges. Recently, firms have been focusing on their use within supply chains (Karkkainen and Holmstrom, 2002). Currently Wal-Mart and Home Depot are among the companies that are conducting tests to determine if the cost savings from increased inventory accuracy are enough to warrant placing RF tags on every item (Bruce, 2002).

These investigations, as well as others, suggest that widespread RF tag use is very near. RF tags have been used for several years in Mobil Gasoline's Speedpass® system, where the customer passes a small key fob within a few feet of the gas pump to turn on the pump and automatically charge their credit card (Ellis and Lambright, 2002). This approach saves time for the customers and lowers costs for the company.

With RFID capability, each store can know exactly what its in-stock inventory is in near-real time. In addition, the distribution centers and warehouses will also have access to current store inventory levels, along with demand trend information, through the use of EDI capabilities. The goal of practitioners and researchers for true quick response (Fernie, 1994) should finally be feasible.

The tag itself is one of two parts of the RFID technology (and network) – the second being the tag reader (also called scanner). RFID scanners sense the items and can query information about each item. Because the network is always on, real-time information about the item can be traced automatically throughout the supply chain. There are various ranges in the frequency for reading the passive or active tags. In general, the data rate is slower with lower frequencies and faster with higher frequencies (Schuster, 2004).

The key factor for widespread RF tag usage is cost. In 2000, RF tags cost about US$1 for a single tag. Currently the cost of RF tags is between 15 and 20 cents. When the cost drops to around 5 cents, experts believe that demand will really take off (Donovan, 2003). Since the semiconductor industry has seen a few years of 50 percent drops in average selling prices, it is likely that RF tags will reach this price point in two or three years. In fact, *BusinessWeek* recently reported that Hitachi has redesigned the antenna for RF tags, and hopes to sell them for as little as four cents each by 2006 (Kunii, 2003). It is further speculated that as the demand for tags increase, so too will the demand for tag readers. The cost of the readers is anticipated to be around US$150 (Schuster, 2004).

While we have already identified some general areas of application of wireless technology to the grocery supply chain, there are specific issues that must be addressed when implementing new technology in the grocery industry.

The future of the grocery industry and technology constraints

As we have pointed out, implementation of ARP techniques has been of limited value because grocery retailers have not changed their forward buying practices. If they are to operate more efficiently, they must adopt technology that will allow them to use their traditional marketing techniques but still decrease costs through reduced inventories. Cohen (2000) outlines how conditions for effective grocery supply chains must change in terms of personnel, communications and inventory reduction, as shown in Table II.

Cohen argues that technology must be the integral part of how manufacturers, warehouses, and retailers communicate with each other. Of specific interest to our research is:

1. communication networks will allow flow-through inventory and JIT delivery between manufacturer and retailer;
2. on-hand shelf inventory in the retail store will be linked to the store's main computer, thus eliminating the use of inaccurate point of sale data;
3. automatic computer reordering will maintain correct inventory levels; and
4. manufacturers will develop modified packing methods and units to minimize the amount of back-stock levels at both the warehouse and retail levels.

Issues 1 and 2 are interrelated. The accurate JIT deliveries, envisioned in issue 1, rely on knowing precisely what the on-hand shelf inventory is. Currently, point-of-sale data is not accurate partly because store check-out-clerks do not scan accurately. For example, when they see nine cans of assorted soup, instead of scanning each separately, they might scan one can and multiply the cost by nine to save time at check out. Data entry errors and theft also contribute to inaccurate inventory records. Thus, some technique is needed to remove the human error from inventory information, and that seems to be RFID.

Issue 3 is easily implemented with current computer capabilities. However, to be effective it must have accurate information on current inventories. This leads to various

Supply Chain Management: An International Journal
Volume 10 · Number 2 · 2005 · 134–142

Table II Pathway to the future

Current conditions	Future conditions	Tools and techniques that will get us there
Personnel		
A few highly knowledgeable people: most workers are minimally trained and educated Limited resources of employees due to cutbacks and downsizing "Command and control" management style	Formation of production teams Highly trained personnel and cross-training within organization Management by integration and self-control	Team concept and management Theory Y use of management techniques Behavioral systems engineering Ergonomics and occupational biomechanics Cognitive engineering design Total quality management
Communications		
Overuse of printed media leading to large waste of paper Delays in ordering stock items due to lack of personnel and lack of feedback to warehouse and manufacturer Delays in price comparison and updates due to long lead times between change and final resolution	Incorporated use of information systems and computers networks to establish rapid communication between retailer, warehouse and supplier to expedite supply requirements, pricing information changes and production problem resolution	Flow process analysis Manufacturing system optimization Operations research Systems management Manufacturing information systems Neural networks Critical path methods/program evaluation and review techniques
Inventory reduction		
Large inventory levels on shelves and in storage at retail level and in warehouse Production difficulty at manufacturer due to excessive or insufficient manufacturing rates	Minimum inventory levels on shelf at retail level. Limited or non-existent inventory levels at retailer and warehouse Production scheduling more closely linked to actual requirement of marketplace Manufacturer's restructured packaging methods for smaller unit quantity per case to help minimize back-stock levels at warehouse and retailer. Improved methods to streamline process and allow for increased unit volume sales	Just-in-time inventory Integrated logistics planning Cost management Engineering economy Regression and analysis of variance Linear and non-linear optimization Production and inventory control Stochastic processes Simulation modeling Dynamic programming Probability applications Production engineering Work measurement Queuing theory Markov chains

Source: Cohen (2000)

topics related to issue 4. Namely, once accurate information is available, companies can move from focusing on functional requirements to supply chain solutions, increasing the visibility of the supply chain and allowing for greater control and efficiencies. In the case of grocery stores, store inventory could even be managed from the distribution center. In that case, grocery stores can take advantage of more efficient reordering policies. This might allow for smaller JIT deliveries, which would allow average inventories to be substantially reduced with minimal impact in customer service levels. With more frequent deliveries, stores might also experiment with smaller case pack sizes. Smaller case pack sizes hold the possibility to reduce both store shelf inventories and warehouse inventories. While reducing warehouse inventories decreases costs, reducing average store inventories is important because this allows stores to make more room on the shelves for additional product varieties. This would allow firms to minimize the category A and C market leakage that was discussed earlier while providing customers more choices

Certain guidelines should be followed when implementing technology within the grocery environment:

- Specifically, the system must not prevent the practice of forward buying (since retailers have shown they will not give it up).
- In addition, the system must allow for more efficient shelf space utilization, thus allowing for a greater variety of products to be displayed. This will allow grocers to grab some of their leaked market share.
- However, this reduced shelf inventory cannot have the negative impact of increasing stockouts. Rather, forecasting must be accurate enough or replenishment must be quick enough so that high service levels are maintained.
- Next, the impact of any modified packing methods must improve supply chain performance.
- Finally, the system must be able to withstand "shocks" in demand and react quickly. These shocks, while infrequent, do occur. For example, a recent Homeland security alert caused a run on duct tape. Unexpected bad

weather can cause a run on milk and bread. The effect of these demand spikes on the reduced in-store inventory must be assessed.

Framework for future research areas

Given the needs and guidelines that have been identified, three fertile areas for future research are suggested: modeling, implementation, and daily operations.

Research using modeling

On the modeling side we propose six general areas/questions that lend themselves to the operational modeling techniques widely used by researchers:

1. If retail store inventory is maintained by the DC, what inventory models should be used?
2. If store inventory is maintained by the DC and they see a need for a product, but that product is currently unavailable, they can substitute a similar product. How would this effect store inventory and service levels?
3. In order to provide greater variety in a limited shelf space, smaller case packs could be used. How does case pack size affect supply chain performance?
4. How does frequency of delivery affect supply chain performance?
5. How does the distribution center's access to current retail store inventory data affect responsiveness and service level?
6. How well can RFID-based supply chains handle extreme demand? In other words, are supply chain results affected by the existence of occasional outlier demands at the stores?

The results of this type of simulation research have a direct impact of category types A and C of the leaked market problems discussed previously. For example, a grocery's entire inventory is on their shelves, so shelf space is at a premium. The use of RFID might allow grocery stores to keep smaller quantities of each product on their shelves while still retaining high service levels. This would allow them to offer more product lines without expanding their stores, which in turn reduces the amount of leaked market from category A and C customers.

Research on RFID implementation

In addition to modeling-based research on operational decisions, researchers need to investigate how to best implement RFID technology in the grocery industry. Figure 4 shows the various barriers to technology adoption. In applying this framework to the grocery industry, we have already seen that there is a compelling reason for grocery stores to manage their operations more efficiently, despite the failure of ARP implementations. The magnitude of effort required to adopt RFID is no greater than that required for ARP implementation. Concerning cost/benefit justification, the fact that Wal-Mart is moving ahead with this implementation (Boyle, 2003) should put downward pressure on the cost of the technology. In spite of RFID's promises, adoption of any new or advanced technology (and the management thereof) includes risks and uncertainty. Further research on RFID applications in the grocery industry, such as the research issues proposed in this study, can help to mitigate many of these risks.

As for entrenched business practices, two key factors were pinpointed in our discussions with grocers. As mentioned earlier, one of the reasons for ARP failures is the desire of grocers to continue with forward buying practices. Research needs to be conducted to see how the use of RFID can be integrated with forward buying if inventories are being managed by the DC. That brings up the second issue that is loss of control by the individual store managers. This is a distinct issue that must be addressed by the grocery chains. However, some corporate supply chain managers believe that it would be easier to implement a system like this because it would be driven by the DC (Carson, 2003; Salmon, 2003).

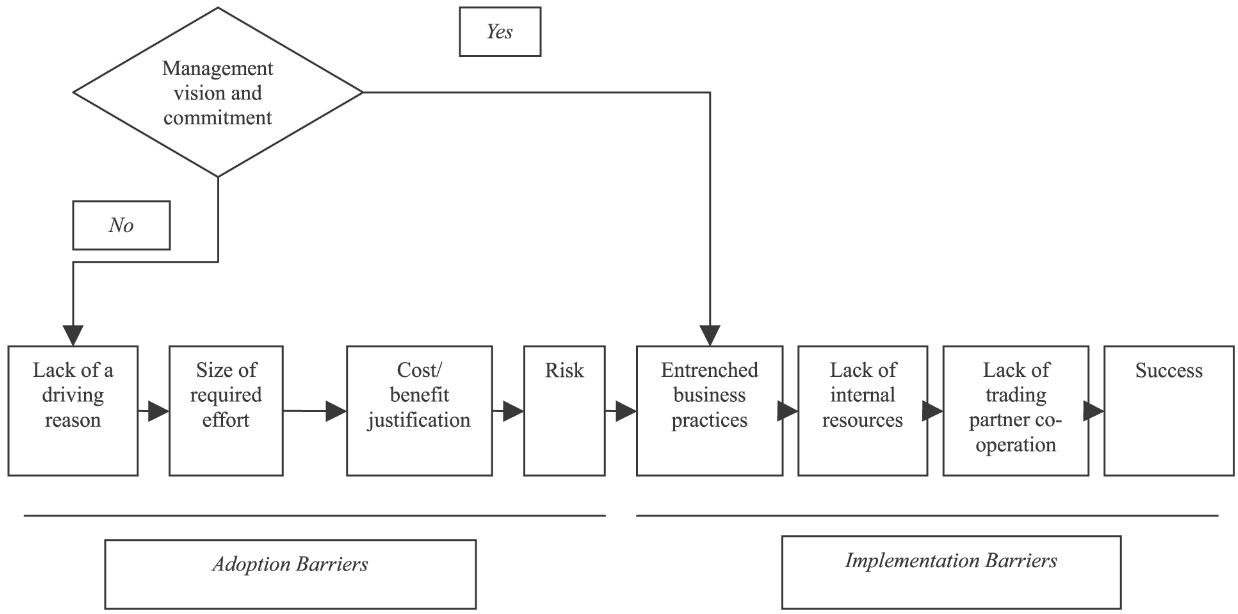
From the view of management, this eases the transition because many store managers are hesitant to learn new technology and operational styles. This is because most managers have moved up the ranks from bag boy. Their focus is instead on customer service and interaction with the customers. Moving ordering decisions to the DC frees up time for store managers to focus on what they would rather do: interact with the customers. This is the traditional view held in process innovation research by Zmud (1984). It is also suggested, by the latest research in innovation, that the best way to implement a disruptive process innovation of this type is to "... centralize the function. Legacy processes are typically embedded in each of the enterprise's operating units. Bring them together under a shared-services model, and put an operations-focused manager in charge. This will free resources that are performing duplicate functions" (Moore, 2004).

Research on daily operations

Within the military, it is said that no plan lasts longer than the first contact with the enemy. In a similar vein, once an RFID technology plan is implemented, grocers must begin to address the daily operational issues that may change the assumptions of the plan. For example, as mentioned earlier, Kurt Salmon Associates argued that forward buying practices are inefficient and if removed could save around $10 billion (10.8 percent of sales turnover) in the dry grocery chain. However, grocers seem to be hooked on forward buying. How would this reliance on forward buying impact RFID use? On one hand, the research may show that RFID use allows firms to better adapt to varying demands and inventories brought on by the use of forward buying. On the other hand, experience has shown that once a technology is implemented, business people search for new ways to take advantage of it. This adaptation may have unforeseen consequences on the use of RFID.

Another daily operations issue that must be addressed is security. Shoplifting is a serious problem in the retail industry. Every year, organized retail crime causes retail loses of $12 billion to $35 billion (Hayes and Roberts, 2003). One method is to stuff stolen merchandize into shopping bags lined internally with duct tape (the duct tape shields the security tags on stolen merchandize from sensors and scanners). An average "booster" steals purely for profit and will steal $5,000 on an average day. Many will make $125,000 per year on shoplifting (IOMA, 2003). Grocery stores implementing RFID must respond to this threat. The costs for increased security measures may somewhat offset the benefits of RFID. But to what degree will these benefits be impacted?

Figure 4 Barriers to technology adoption



Source: Fernie (1994)

Summary

RFID is an intriguing technology that has garnered a great deal of research interest. However, that research has primarily focused on RFID's impact on general supply chain issues; failing to place the discussion within a specific business domain. This is necessary because the strategic environment of any business impacts the applicability of any technology. In this paper we have considered RFID research within the context of the grocery industry. We have outlined the market drivers that affect the way the grocery industry approaches RFID. We have also outlined specific areas of research on RFID that should be undertaken to better provide the grocery industry with managerial insights into this technology's application. These research areas include research using modeling techniques, RFID implementation and the impact of RFID on daily operational issues.

We believe that the adoption of RFID technology and its attendant supply chain management techniques holds the promise of being more successful than the ARP implementations of the 1990s. This should encourage research into this area, for as researchers provide insights into these issues, the grocery industry can immediately put the findings into practice.

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