Increasing efficiency in the supply chain for short shelf life goods using RFID tagging

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Keywords

Data encapsulation, Identification, Tagging

Abstract

Short shelf-life grocery goods present some of the biggest challenges for supply chain management due to a high number of product variants, strict traceability requirements, short shelf-life of the products, the need for temperature control in the supply chain, and the large volume of goods handled. A Radio Frequency Identification (RFID) based data capture system can help solve the problems associated with the logistics of short shelf life products. This article discusses the potential of utilising RFID technology for increasing efficiency in the supply chain of short shelf life products. The focus of this article is a RFID trial conducted at Sainsbury's, which is discussed to study the potential benefits of RFID for short shelf-life products retailers. Further this article analyses the potential impact of RFID for other supply chain participants. We conclude that when applied with recyclable transport containers, RFID investments can provide quick amortisation of capital whilst offering a range of operational benefits.

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Introduction

Short shelf-life goods present some of the biggest challenges for supply chain management (Shulman, 2001; Dilger, 2000). Supply chain management is challenging, and important, in the field of short shelf-life grocery goods owing to a high number of product variants, strict traceability requirements, short shelf-life of the products, and the need for temperature control in the supply chain (Kantor *et al.*, 1997; Töyrylä, 1999; Bubny, 2000; Raman *et al.*, 2001). Furthermore, the large volume of goods moved in the supply chain makes efficient practices a necessity, as small percentual changes in operational cost add up to significant amounts, thereby impacting on profit margins. Efficient supply chain management is, therefore, of paramount importance in the field of short shelf-life goods.

The goal of cost efficiency and a continuous cool-chain makes fast handling a requirement in the supply chain. As large volumes of goods are handled, all savings in time in handling become an important competitive advantage. From the temperature control point of view, all operations that are not performed in chilled premises need to be completed promptly. For example, expediting the loading and unloading of trucks, reduces the risks of contamination of goods (Shulman, 2001).

The number of product variants in the short shelf-life category has increased over a relatively short period of time due to an increase in the offering of ready meals and pre-packed meat products. The high number of product variants greatly increases the complexity of supply chain control, and thus often degrades supply chain performance by causing scheduling, capacity planning and inventory management to be more complex (Cooper and Griffiths, 1994; Raman *et al.*, 2001). It is, for example, difficult and time-consuming to forecast the consumption of all variants (Holmström, 1997). Only a limited amount of safety stock can be held due to the limited shelf-life of products, and

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therefore the availability of the products cannot always be ensured (Kranendonk and Rackebrandt, 2002).

Spoilage is an additional problem in the short shelf-life product supply chain, and it is caused principally from excess stock and flawed stock rotation. Effective stock rotation ensures that products are taken from the storage in the correct order, as determined by their sell-by dates (Shulman, 2001). The scope of the problem is extensive. For example, in one Nordic retailer, the spoilage costs of are in excess of 10 percent of total sales for all short shelf-life products. Moreover, in the European grocery sector, products that are not purchased before their sell-by date are estimated to cause yearly costs of billions of dollars (Leicester University and Cranfield University, 2001). Correct rotation and the minimisation of supply chain inventory are keys for reducing spoilage.

It is clear, therefore, that an effective information collection system helps to solve the challenges in supply chain management for short shelf-life products. Efficient capture of data in the supply chain helps to track channel inventory and sell-through. This provides transparency of the supply chain and, thus, helps create more accurate forecasts and supports the optimisation of stock replenishment quantities. Increased visibility also helps in timing replenishments more accurately. Optimised replenishments help to lower spoilage while keeping product availability at an acceptable level. Visibility and the opportunity to interrogate the distribution chain also enables detecting shortages and overstock as they occur and, thus, helps in reacting before threats materialise.

At the moment barcode-based applications are widely used in the short shelf-life supply chain. Various types of scanning equipment, ranging from fixed readers to finger scanners, are used in many phases of the distribution network (Banks, 2001a). Barcode scanning reduces errors associated with manual data handling, and produces visibility to aid supply chain management (Fraza, 2000). Also, the introduction of new bar coding standards that enable adding the sell-by dates to the codes have helped in retaining the integrity of stock rotation and hence help solve the spoilage problem (Shulman, 2001; *Frontline Solutions*, 2001).

However, there *are* problems associated with barcode data collection. The reading of barcodes invariably requires manual handling in the supply chain. Either the packages with barcodes or the reading devices are handled manually in order to read the codes (Boxall, 2000; Bylinsky, 2000; Jones, 1999; Moore, 1999). This makes data capture difficult, especially in the retail store environment where large amounts of goods are handled in facilities not designed for effective logistics (Fidler, 2001). Readability of barcodes is, occasionally, problematic due to dirt and bending; resulting in reduced accuracy of reading rates, particularly in successive handling situations and in difficult environments (Ollivier, 1995; Moore, 1999).

Radio frequency identification (RFID) is a technology that can help provide operational efficiencies and improved stock level transparency in short shelf-life products distribution. RFID systems incorporate electronic devices called transponders and reading units. Transponders are more commonly known as tags and they are attached to the items to be identified. RFID readers communicate with the tags via electromagnetic waves (d'Hont and Frieden, 2000). In the short shelf-life products supply chain, when comparing RFID and barcodes, considerable strengths of RFID are that it does not require line of sight between tags and a reader in order to be read, tags can be read through non metallic materials and approximately sixty tags can be read simultaneously (Boxall, 2000; Jones, 1999; Lindström, 2000). This results in, for example, a roll cage loaded with products being read at one pass by the reader. Most tags are resistant to environmental temperature and other external factors, and can be read and re-programmed at least 300,000 times before replacement (DeJong, 1998). Therefore, when utilised in recyclable transportation containers, the same tags can be used many times.

The cost of tags varies dependent on the specified performance requirements of the operations. Low cost tags, applicable to grocery industry, cost from 20p to 35p, and latest tag developments promise tags costing just over 5p (Gould, 2000; Little and Arnst, 2002). The price of RFID readers varies between £1,800 and £18,000, depending on the type of reader (prices quoted from Omron Finland).

The aim of this paper is to study the potential of using RFID technology to increase the efficiency of the supply chain for short shelf-life products. In the first section of the paper, we will review highly significant aspects of RFID technology

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together with discussion concerning its applicability to the grocery business. In the second part, we will present a case study of an RFID trial completed at Sainsbury's, in the UK, to study the benefits that RFID technology offers to the distribution of short shelf-life products. The third section reviews implications for other supply chain participants. Concluding remarks discuss our key findings and, finally, future research opportunities are explored.

Background

RFID has been presented as one possible key technology in building more effective grocery supply chains (Rizzotto and Wolfram, 2002). The subject was, for example, on the agendas at the 6th ECR Europe conference in Glasgow, the 2001 CIES Intelligent Supply Chain conference in Amsterdam, and was discussed in the 2001 IGD Retail Logistics review. However, two controversial opinions have been presented of its applicability to the grocery supply chain: one highlights the advantages the technology offers over barcodes, and presents views of possible benefits with the use of RFID (Ashton, 2000; Bushnell, 2000; Chamberlain, 1997; Hawkes, 1994; Milner, 1999), while the second view emphasises the cost of the technology and argues that the attainable benefits are unlikely to off-set the high capital investment required (Burnell, 1999; Riso, 2001).

Those pro-RFID have presented scenarios where the use of RFID offers substantial benefits in the grocery business. These suggestions include attaining savings in cost through automating the check-out process (Chamberlain, 1997; Hawkes, 1994), reducing labour associated with performing inventory counts of shelved goods (Bushnell, 2000; Milner, 1999), improving theft prevention with shelves that report if a large amount of goods are removed, and increasing authenticity control (Ashton, 2000). In these scenarios, the benefits described are often significant, and a total re-appraisal of the grocery supply chain is promised. However, an exact description of how the benefits are attainable in practice has often remained vague, and the process and cost of implementing the solution have not been explained.

Critics of RFID's applicability in the grocery supply chain have claimed that the envisaged scenarios are based on optimistic assumptions, and the visions are likely not to be realised. Their main criticisms are that RFID technology is too expensive, and that it is unlikely that the investment will pay off (Burnell, 1999; Riso, 2001). Additionally, critics often indicate that RFID is an over-marketed, hyped, technology, and that the existing barcode based systems already provide most of the needed functionality (Burnell, 1999).

With the current cost of RFID technology, investment in tagging for consumer packaging is not likely to be profitable. However, if tagging is applied at the transport-unit level, i.e. transport cartons, and not for individual consumer packages, then many of the potential benefits can be achieved with a considerable reduction in capital investment. The greatest cost efficiency can be achieved with recyclable transport containers, as the same investments in transponders can be continuously utilised (Albright, 2002).

It is a common practice for UK retail chains to use returnable containers to distribute short shelf-life products (IGD, 2001). Returnable containers induce costs in the supply chain via investment needs and the need to control the containers themselves, but in many cases the savings in packaging material and better protection to the products outweigh the costs (Twede, 1993; *Modern Materials Handling*, 1999, 2000; Maloney, 1999; Kroon an Vrijens, 1995). Moving to recyclable containers has provided cost savings for UK based companies (Shipley, 2000). Recyclable transport containers are also often used in other countries, for example Ahold as well as the Finnish grocery business operate using them (Luukkonen, 2002; van Abeelen, 2002).

This paper focuses on applications based on recyclable transport units as at current cost of technology these applications have the greatest payback potential, as the cost of the tag is less of an issue when it can be utilised in successive rounds of the container.

The value of RFID for the retailer – the Sainsbury's case

In this section, we discuss the effects of RFID tagging from the viewpoint of retailing and

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distribution, namely the case study of Sainsbury's RFID trial.

The information on Sainsbury's RFID trial is gathered from a case interview with Ian Fidler, the senior manager of supply chain development at Sainsbury's. Additional information was sourced from conference presentations, published papers, and the Internet (Banks, 2001b; Boxall, 2000; Burnell, 1999; Philips Semi-conductors, 2002). The case interview with Mr Fidler was conducted in December 2001. In total ten open-ended questions were used in the interview (see Appendix).

The starting point for Sainsbury's RFID trial

The Sainsbury's RFID trial was planned on the basis of a vision of an information enriched supply chain, where all disruptions could quickly be dealt with prior to causing major problems. The vision was established in 1998.

Currently, short shelf-life products are packed on plastic transportation crates, in which they are distributed to the stores from the suppliers' production facilities through Sainsbury's distribution depots. The crates are equipped with barcodes that are used in the depots in addition to the stores.

Later, Sainsbury's decided to proceed with investigating RFID, and conduct a trial to establish the benefits that it could achieve with the technology. Subsequently, two more practical goals were set to the trial:

(1) Reducing labour associated with stock counting and rotation monitoring in stores.
(2) Reduce spoilage in the supply chain.

The retail store was selected to be the focus area of the trial, as the store environment presents the biggest logistics challenges in the grocery supply chain. Automating the management of store inventory was selected as a major aim of the test, since current practices in inventory management within the store environment is labour intensive, difficult, and prone to errors. This is due to the amount of effort in to tracking all the movements of products with barcode-based solutions. Spoilage could be reduced simultaneously by automating inventory management, if the use-by dates of products were automatically obtained while handling along the supply chain.

The solution for the retail store problem was developed so that all unit containers with chilled products were automatically scanned with a portal reader, whether they were received into backroom facilities or moved in any direction between the backroom and store area. The scanning was completed while the products were moved in roller cages through the gate. In addition to the description and the quantity of the moved products, their use-by date was recorded to address the spoilage issue as well as inventory management.

An RFID trial was set up as it was seen as an emerging technology with costs that were constantly declining. The rationale was that this technology could also be useful in the future in a large range of other potential applications. The most important issues in RFID functionality from the retail viewpoint were that no line of sight is needed to read the tags; and the possibility of batch reading. These enable the reading of tags in product crates without a need for separate handling. This was considered especially important in the retail store environment where the trial was focused.

The trial in practice

In the Sainsbury's RFID trial, tracking focused on chilled goods. The trial started with one ready-meal supplier, a single depot, and a retail store. Later, the trial was scaled up to encompass all chilled products going to the retail store.

The trial was based on applying RFID tags to recyclable plastic crates. The programming of the RFID tags is accomplished by the reading devices encoding information to the tags' memories. Programming is possible on tags in the reading area of the reader.

Three pieces of information were needed to fulfil the goals of the trial, i.e. faster and better controlled stock rotation, especially in retail stores, and were programmed to the tag:

(1) the description and quantity of products in the crate;
(2) the use-by date of these products; and
(3) the crate's own ID number

In instances that additional application possibilities providing extra value were identified the memory capacity of the RFID tags proved sufficient. The memory capacity of the tags did not appear to be a limiting factor during the trial.

At the beginning of the trial, all tags on crates with chilled goods produced at the one supplier were programmed with the description of the product and the use-by date of the products.

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The programming was completed with a reader at the end of the production line. Next, the goods were read at the depot's goods receipt with a portal reader. This reading method enables operational efficiency as all crates in a pallet or a roll cage can be read by a single movement through the reader. When delivering to the store the goods were again read with a portal reader that was located between the chilled storage and store areas. The goods were always moved through the reader, whether moving them in or out of stock.

To achieve a more accurate estimation of the available benefits and to get a clear vision of the possible problems, the test was scaled up. In the scaled-up test, all crates used in distributing chilled products to the test store, i.e. products from all suppliers to that store, were equipped with RFID transponders. The programming of products was completed with a portal reader at the depot as a part of the goods receipt procedure. Thus, all chilled product crates delivered to the store were equipped with RFID tags, but only the one initial supplier was participating in the scaled-up trial. The programming was carried out so that relevant information was read from barcodes on the crates after which the crates with tags were moved through a profile reader and the information was programmed to the tags.

The setting and procedure used in Sainsbury's RFID trial are summarised in Figure 1.

The effects of this scale-up were that all products arriving to the test store were equipped with RFID tags, allowing easy access to product description, product quantity and use-by date information. This scaled-up test was run for three months to reveal the effects that the use of RFID may have on retail store operations. This was considered essential for accurate estimations of potential benefits.

The benefits and costs associated with the Sainsbury's RFID solution

Many of the quantifiable benefits through the trial were identified in the retail store. To calculate store-level benefits, Sainsbury's used their labour standards. Labour standards are work study timings for all key activities in store processes. The activities consist of detailed component tasks. In the trial, the activity times were re-measured to compile a new labour standard for RFID-based store processes. General observation and the experiences of store personnel were used to validate the new labour standard. This new labour standard was then compared with the existing labour standard to find out the savings potential.

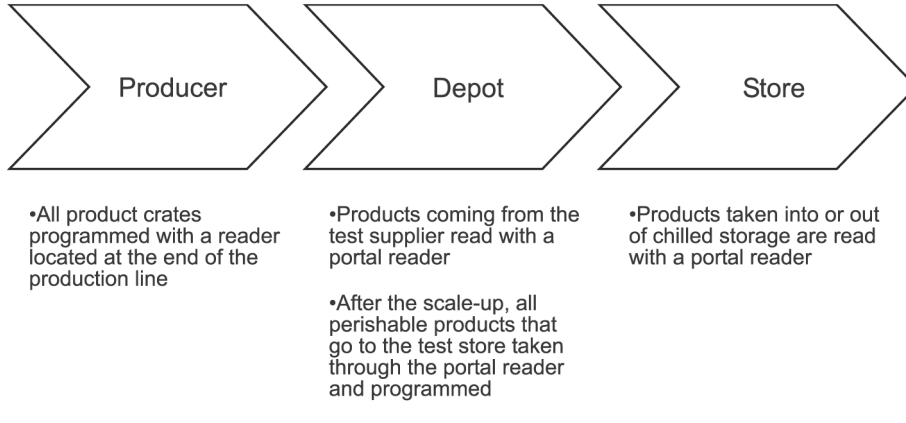
The total benefits achievable for Sainsbury's with a full-scale implementation without supplier participation were estimated to be £8.5 million a year. Only straightforward benefits resulting from more efficient stock rotation and control are accounted for in the figure, possible new operations models are not included. The break-down of the estimated savings is presented in Table I.

Much of the estimated savings related to retail store replenishment productivity and reduction of stock-loss. Improved

Table I The breakdown of the total savings with RFID based tracking

Origin of the savings	Amount of savings
Depot inventory control	£130,000
Store receiving	£294,000
Stock/code check	£2,556,000
Replenishment productivity	£1,425,000 (primarily in store)
Stock loss	£4,117,000 (primarily in store)

Figure 1 The setting and procedure in Sainsbury's RFID trial



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replenishment productivity was achieved through increased asset visibility. The reduction of stock-loss was due to increased inventory accuracy and better control of stock rotation.

The investment needed for the system was calculated to be between £18 million to £24 million. The reader and tag costs used in calculating the capital investment were £6,000 and £8,000 for readers, and 30p and 65p for a tag. On the basis of the estimated savings and the investment needed we conclude that the payback period of the RFID system would have been between two and three years.

A noteworthy and important aspect is that this solution provides significant benefits even without supplier participation, which required all the crates to be programmed as they entered the depot. If suppliers participated fully in the process then the achievable benefits would be notably larger. Non-participation required the programming of the crates as they were received in the depots a causing bottleneck. Also, further automation of data collection and handling in the depot would be possible if crates were programmed at the ends of production lines. Supplier participation would, of course, also increase the investment costs, as readers would have to be installed at the end of production lines.

However, suppliers were considered unlikely to be willing to invest in the readers due to the, unproven level of the technology, and the lack of standards. Partly owing to the lack of supplier confidence and the required development efforts on the system, Sainsbury's decided not to proceed to full-scale implementation at that moment in time. Also, Sainsbury's had other business priorities to address.

Potential benefits for other supply chain members

From the trial performed at Sainsbury's, we can conclude that when utilised with recyclable transport containers, RFID offers retailers investment possibilities with a tangible return on investment. This is achieved by tags recurrently being utilised in the delivery process. Of importance, is that the trial was investigating possibilities of RFID from the viewpoint of a retailer. However, the suppliers can also achieve benefits, and supplier participation would increase the benefits of the retailer resulting from operational synergy.

The most notable benefit for the supplier is the potential to reduce the out-of-stock rate of suppliers' products. The reduction of the rate of stock-outs often benefits suppliers more than the retailer, as the consumer almost invariably picks a substituting product. Short shelf-life products belong to categories with most brand switching when there is stock-outs. (Kranendonk and Rackebrandt, 2002). The savings potential is large, as the average stock-out rate in supermarkets is between 7-10 percent, while in short shelf-life products the rate is on average as high as 18 percent, due to the difficulties of managing the short shelf-life products supply chain (*Supermarket Business*, 1996; Kranendonk and Rackebrandt, 2002). Therefore, it should be possible to encourage suppliers to invest in RFID systems, as the investment needed can be as low as £3,500. Further benefits can also be achieved with, for example, automated proof of delivery applications (Agarwal, 2001), automatic invoicing (Fidler, 2001; Millstein, 1994), and more robust proactive replenishment (Kaipia *et al.*, 2002; Kärkkäinen and Holmström, 2002).

Container providers such as Chep and a Finnish provider Transbox, have been considering tagging their transport containers (Burnell, 2002; Luukkonen, 2002; Klein, 2000; Robson, 2002). Tagging would help in managing the containers more efficiently, and the costs of the tags could also be partly offset by collecting a premium on the rental charges of the tagged containers (Rizzotto and Wolfram, 2002). CHEP, in the USA, has engaged in a large scale trial to test RFID in tracking its equipment, and argues that it has a good business case if the technology proves functional (Robson, 2002). The actions of container providers are important, as their decisions whether or not to tag crates greatly influence the investment requirements of the companies operating the supply chains.

Concluding remarks

An efficient data capture system can help solve the challenges that short shelf-life products present to supply chain management. We can conclude that the available benefits justify RFID tagging in recyclable transport containers. It begs the question, therefore, why are there no existing wide-scale applications?

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Several reasons for the lack of running applications can be found: first, there has been a lack of systems integrators, the companies investing in RFID would have had to build the systems itself from parts offered by technology providers. Second, the biggest benefits can be gained from solutions spanning throughout the whole supply chain. Commencement is difficult, due to disputes regarding sharing the cost and benefits (Kärkkäinen and Holmström, 2002). Third, RFID technology is not standardised. There are numerous proposals for standards waiting to be ratified (Logistics *Management and Distribution Report, 2000b;* Burnell, 2000b), and there are also competing standards for transport unit level tagging (Burnell, 2002; Cooke, 2001). It is difficult for companies to know which technology or standard will prevail. Thus, investments are curtailed due to the risk of choosing a technology that will lose the standardisation battle.

It can be argued that a supply chain-wide initiative can help develop the distribution of short shelf-life products to an extent that would provide quick payback of capital investment. The key is to utilise the technology in recyclable transport containers, and develop processes spanning through organisational boundaries, so all parties can benefit from the technology.

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Appendix. Interviews questions

- What was the specific business problem Sainsbury's was trying to address by developing the RFID tracking system?
- Why was RFID technology selected to be used in the system?
- What was the structure of the test supply chain?
- What specific difficulties did the extension of the solution over organisational boundaries cause?
- What information was programmed into the tag and why those pieces of information were chosen?
- How was the reading system constructed? Where were the readers located and why those locations were selected?
- How was data communicated between the readers and information systems arranged?
- What (and how large) benefits were achieved?
  If the benefits are not explicitly calculated would any information to quantify the benefits be available?
  Specifically, what measures were affected by the solution?
- What was the technical construction like in a functionality point of view?
- Why the decision not to take the system to operation was made?