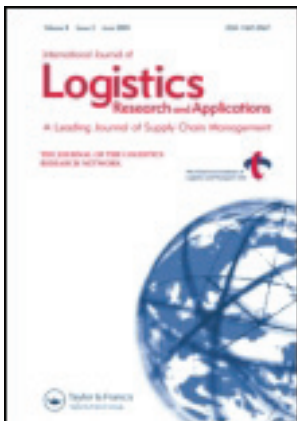


Publication III

Hinkka, Ville; Holmström, Jan & Främling, Kary:
RFID tracking in the book supply chain: The transition from postponed to
speculative tagging,
International Journal of Logistics: Research and Applications, Vol. 15, No 3.
2012. Pp. 194-214.

Reprinted with permission from International Journal of Logistics: Research and
Applications.
© 2012 Taylor & Francis

This article was downloaded by: [Aalto-yliopiston kirjasto], [Ville Hinkka]
On: 14 August 2012, At: 01:19
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/cjol20>

RFID tracking in the book supply chain: the transition from postponed to speculative tagging

Ville Hinkka^a, Jan Holmström^a & Kary Främling^a

^a Department of Industrial Engineering and Management, Aalto University School of Science, PO Box 15500, FI-00076, Aalto, Espoo, Finland

Version of record first published: 03 Aug 2012

To cite this article: Ville Hinkka, Jan Holmström & Kary Främling (2012): RFID tracking in the book supply chain: the transition from postponed to speculative tagging, International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management, 15:3, 199-214

To link to this article: <http://dx.doi.org/10.1080/13675567.2012.709834>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

CASE REPORT

RFID tracking in the book supply chain: the transition from postponed to speculative tagging

Ville Hinkka*, Jan Holmström and Kary Främling

*Department of Industrial Engineering and Management, Aalto University School of Science,
PO Box 15500, FI-00076 Aalto, Espoo, Finland*

(Received 21 April 2011; final version received 2 July 2012)

This paper addresses the question regarding the point at which books should be tagged in the book supply chain, and where tracking could begin at different levels of adoption among retailers. Alternative solution designs are analysed by comparing the costs and benefits of the supply chain-wide radio frequency identification (RFID) tagging with RFID tracking solutions that cover only part of the supply chain. The analysis is based on modelling the RFID tag as a product feature and considering the tagging of books as a potential postponement decision. The cost estimates are based on activity-based costing and used to compare alternative solution designs for introducing RFID tracking in book retailing. Attaching RFID tags in the manufacturing phase is in many settings likely to be cheaper than downstream tagging. However, early tagging requires a threshold share of retailers to adopt RFID tracking in their store operations and be willing to bear the additional product costs.

Keywords: radio frequency identification; tracking; modelling; supply chain management; printing industry; retailing

1. Introduction

The use of radio frequency identification (RFID) for tracking in supply chains has increased in the past few years. However, the majority of existing RFID tracking solutions have been designed for the purposes of a single organisation such as a retailer, and not as a supply chain-wide system. As an illustration, consider one of the best-known and largest RFID implementations by Wal-Mart, the US-based retailer. The implementation is based on Wal-Mart's strong position as a buyer and its power and control over suppliers. Suppliers attach RFID tags only on shipments to Wal-Mart, and only because they are obliged to do so. Very few suppliers even consider using RFID-tracking in their own operations and see little benefits of RFID tracking for their operations (Vijayaraman and Osyk 2006).

However, supply chain management is based on the concept of cooperation between supply chain members and the notion of competition between supply chains, not supply chain members (Christopher 1998). From this perspective, RFID tracking solutions that only increase the

*Corresponding author. Email: ville.hinkka@aalto.fi

performance of one supply chain member and overlook the use of the same tag by other supply chain members with few extra costs are wasteful. Spekman and Sweeney (2006) recognised this problem and demonstrated how supply chain-wide RFID tracking is dependent on collaboration between supply chain members.

Tracking systems currently introduced by retailers to improve store operations seldom exploit RFID technology, even in industries where the potential benefits have been clearly demonstrated, as in book retailing (Kroon *et al.* 2007). The challenge is that attaching RFID tags on products that are handled by companies who are unable to utilise the tags causes unnecessary costs. This paper studies the circumstances under which it is useful to tag books upstream in the book supply chain. The question is especially analysed from the perspective of a retailer company, who is adopting or interested in adopting RFID technology to improve its operations, but may find upstream supply chain members reluctant about the technology. The findings are based on an in-depth case study of a supply chain whose members are a large book retailer, a distributor, a publisher and two printing houses. The study contributes to understanding the conditions under which adopting RFID tracking by retailers increases the possibility of upstream tagging upstream, and introducing RFID tracking into the operations of upstream supply chain members.

The paper is divided into five sections. After this introduction, Section 2 describes the current literature regarding the research question. Section 3 presents the methodology used in this paper, Section 4 presents the case, and finally, Section 5 presents the conclusions and managerial implications.

2. Literature review

The literature review starts by presenting RFID technology and its solutions in the book industry. The RFID literature highlights the fact that the biggest benefits of the technology come from supply chain-wide implementations and improved supply chain visibility (e.g. Kärkkäinen and Holmström 2002, Attaran 2007). In practice, however, large solutions spanning several supply chain members are still relatively scarce. Current RFID literature speaks very little about different supply chain locations to attach RFID tags. Therefore, we have reviewed supply chain management literature to find ways to handle the research question. We found that the widely used supply chain management concept of postponement and the opposite concept of speculation are used as a strategic approach to handle similar supply chain management decisions as those considered in this article, and thus could also be used to analyse tagging locations in the supply chain.

RFID is mainly used for tracking purposes in the supply chain. An RFID tracking system consists of three primary components – tags, readers and tracking databases (Attaran 2007). Tracking systems are based on checkpoints that register the movements of tracked items (Loebbecke and Powell 1998). The benefits of tracking are real-time coordination of material flows and individually tracked items, such as merge-in-transit; providing an effective link between physical reality and information systems, such as improved stock-taking and goods receipt transactions; and improved logistics management metrics and analyses (Stefansson and Tilanus 2001, Kärkkäinen and Holmström 2002, Ala-Risku *et al.* 2003, Kärkkäinen *et al.* 2004, Holmström *et al.* 2011). RFID also enables the automation of operational supply chain processes and creates possibilities to offer information to support managerial processes (Visich *et al.* 2009). Several successful examples of RFID implementations have improved supply chain operations considerably and brought significant savings for the companies that adopted the technology (Attaran 2007, White *et al.* 2008). RFID technology has also brought added value to many supply chain operations (Lin and Ho 2009) and even opened the doors for new business opportunities (Martinez-Sala *et al.* 2009).

There have been worldwide reports on RFID trials and applications in bookstores around the world. Hou and Huang (2006) evaluated six different possible adoption models for RFID applications to the Taiwanese book industry and estimated the costs and benefits for different models. The Dutch bookstore chain Selexyz has three so-called 'intelligent' bookstores, in which each book sent to these stores is first marked with an RFID tag by the local book supplier company Centraal Boekhuis (Schonfeld 2006, Trebilcock 2006, Kroon *et al.* 2007). The Portuguese bookstore chain Byblos opened a 4500 m² bookstore in Lisbon in December 2007, and all of its 350,000 books, games and videos are equipped with RFID tags. Byblos tracks its items itself by attaching RFIDs to every product when they arrive at the bookstore (IT Reseller Magazine 2008, Swedberg 2008). Loebbecke and Huyskens (2008) reported about the METI (Ministry of Economy, Trade and Industry) RFID trial in the Japanese publishing industry, which included item-level RFID-tagging of 100,000 comic books during the manufacturing process. Swedberg (2009) reported that a Japanese publisher attaches RFID tags to its books to improve the handling of book flows between the publisher and retailers.

The literature clearly indicates that retailers get the biggest benefits from RFID technology, regardless of the industry (e.g. Twist 2004, Vijayaraman and Osyk 2006, Soon and Gutiérrez 2008). In book supply chain implementations, the biggest benefits come from increased sales. After implementing RFID technology, sales at Selexyz's 'intelligent' bookstores increased more than 10%, which is considerable compared to the total sales increase in book retailing in the Netherlands, which has been close to zero. In addition, Schonfeld (2006) reported that sales in the company's Almere bookstore have been 25% higher than in other similar stores in the area since the system was installed. Those increased sales arose from the improved availability of titles and improved customer service. Rekik *et al.* (2007) considered these benefits when discussing the scope for RFID technology to decrease retailers' out-of-stock situations that arise when only one or a few items of many SKUs (stock-keeping units) are available in each retail outlet, and Wong and McFarlane (2007) demonstrated how RFID can be used effectively in shelf replenishment and to increase availability of products and sales. The faster receipt of shipments and handling of customer-ordered books are also significant benefits that RFID technology offers. Also, the backroom space needed for receiving is much smaller in Selexyz's 'intelligent' bookstores than other bookstores with similar volumes. RFID technology speeds up stock-taking considerably, but also other processes, such as shelving, have also become faster, thus providing additional savings after implementing RFID (Hadfield 2006, Kroon *et al.* 2007).

Among the book supply chain examples in the literature, the METI RFID trial is the only implementation that attaches tags in the manufacturing phase (Loebbecke and Huyskens 2008), even though RFID tagging during the manufacturing phase was one of six identified RFID tracking implementation scenarios for book supply chains presented by Hou and Huang (2006). The Dutch book logistics service provider (LSP), Centraal Boekhuis, attaches RFID-tags to the books ordered by Selexyz's 'intelligent' bookstores (Kroon *et al.* 2007). Lisbon's Byblos attaches RFID tags to all its books and other products that are shipped to the bookstore (Swedberg 2008). The main reason that Byblos attaches RFID-tags itself (instead of the wholesaler or the LSP) is due to Portuguese law, which demands that the retailer mark the retail price of the product. Therefore, Byblos has found that it is easier to attach the RFID tag for a product at the same time as it attaches the price tag.

The successful examples of Selexyz and Byblos show that book retailers could gain considerable benefits by exploiting item-level RFID technology, and these retailers seem to be pleased with their RFID system designs. However, the original purpose of improved tracking is to increase the visibility of the entire supply chain (Kärkkäinen and Holmström 2002, Attaran 2007), and that objective may be fulfilled only if the starting point of RFID tagging and tracking is moved farther upstream in the supply chain. However, designing RFID-tracking solutions that span the entire supply chain is difficult (Spekman and Sweeney 2006). The costs are, of course an important issue when considering the RFID tracking system implementation. Smart *et al.* (2010)

have recognised that in RFID adoption by early adopters, the following cost factors are relevant: development, switching, cost of capital and implementation. The other things that prevent supply chain-wide RFID technology adoption include the fear of increased power of large retailers (Curtin *et al.* 2007, Soon and Gutiérrez 2008), or the so-called free-rider problem (Whang 2010). This means that downstream members of the supply chain wait for an upstream supply chain member to implement RFID so that they can use the same tags without incurring extra tagging costs. Some authors who have recognised this problem call for further research regarding the potential benefits that manufacturers and LSPs could realise in order to make RFID technology more desirable to them (Soon and Gutiérrez 2008). Still, current RFID literature does not provide a theoretically insightful explanation as to why RFID tracking solutions are mainly limited to the use of individual retailers.

As the RFID literature does not propose an explanation regarding why the technology has not spread to supply chain-wide solutions, the basic supply chain management literature is reviewed. A central tenet of supply chain management is that competition is now between supply chains, and their members need to cooperate if their supply chain is to be competitive (Christopher 1998). In such situations, moving activities between supply chain members where it is most cost-efficient and where it introduces innovative practices is in each supply chain member's long-term interest.

In the supply chain management literature, postponement (Bucklin 1965, Van Hoek 2001, Yang *et al.* 2004a, Boone *et al.* 2007) is a frequently used approach when dealing with customer-specific requirements and new ways of working, such as RFID tracking. Even though the majority of the articles about postponement are written on a company level (Yeung *et al.* 2007), the concept also applies to the supply chain level. The main idea regarding postponement is that if differentiation of the goods can be postponed until the final customer commitments have been obtained, risks can be reduced or fully eliminated. Bucklin (1965) also defined the opposite concept, speculation. The principle of speculation would mean that RFID tagging would be made at the earliest possible time, for example, when the product or its key component is manufactured or assembled, in order to reduce the cost of handling and control in later stages of the supply chain, and in order to gain economies of scale in tagging. In the RFID tagging context, speculative tagging would mean that all the tagging is done before the supply chain members know, how big a share – if any – of the tagged products will end up in those parts of the downstream supply chain which are able to use and gain benefits from these tags. Postponed tagging, on the other hand, would mean that only those products which are known to end up with RFID using customers will be tagged, which will restrict the amount of money needed to be spent on RFID tags.

The experiences of early adopters of RFID tracking systems point to two alternative solution designs (Vijayaraman and Osyk 2006): Retailers can either tag the products themselves or demand that their suppliers tag the ordered products. From a supply chain perspective, both alternatives represent postponement solutions that forsake the potential benefits of RFID tracking outside retailing, as well as increase the cost of tagging compared to tagging in the manufacturing stages.

In this paper, we propose that an important reason for the lack of supply chain-wide RFID tracking systems is due to the difficulty of moving between postponement and speculation (P/S). Pagh and Cooper (1998) present generic supply chain strategies that combine manufacturing and logistics P/S. They identified four different supply chain strategies in their model: full speculation, manufacturing postponement, logistics postponement and full postponement – but they did not elaborate on the transitions. Yang *et al.* (2004b) provides a wider, more integrated framework that shows postponement as a comprehensive strategy, capable of restructuring supply chains, but does not provide guidance regarding how to proceed to effectively introduce item-level RFID tagging and tracking at the supply chain level. Therefore, in this paper, we can use postponement versus speculation as a tool to understand that the companies that are interested in adopting RFID technology should consider the system design from a supply chain point of view, instead of searching for an optimal solution for a single company, as seems to be the situation today.

3. Methodology

Because the literature on the research topic is scarce, and no suitable, open, supply chain-wide RFID implementation has been identified in which the research question could be tested, different methods were combined to obtain reliable answers to the research question without the need for building such an RFID system.

The primary method used in this paper is a single-case study (Yin 1994). The case is a Finnish book supply chain. The case was analysed by using qualitative methods such as interviews and direct observations. As a result of employing the qualitative methods, quantitative modelling could also be used (Bertrand and Fransoo 2002). Modelling consists of a quantitative cost model, where the costs and realisable benefits of RFID technology were calculated by comparing different RFID tracking scenarios. There are several actors in the case study book supply chain. Publishers decide which books are printed and the size of the edition. Printing houses print the books according to the instructions and material provided by publishers. In Finland, the biggest book LSP is owned by almost 200 notable actors in the Finnish book industry. This LSP stocks and transports the majority of the books sold in Finland in any distribution channel. The company also acts as a traditional wholesaler, but on a very small scale. The main distribution channels for the books are bookstores, other stores, and mail deliveries from book clubs or web stores. The following companies participated in the case study:

- One publisher, who has an approximate 20% market share in Finnish book publishing.
- Two printing houses, both of which have about 20% of the market share of the printing of books sold in the Finnish market.
- The LSP, whose business is described above.
- One bookstore chain, which sells around half of all the books sold in bookstores in Finland.

The primary method used to gain an understanding of the situation was interviews with the logistics and information system managers of the case supply chain companies. Direct observation was also a major data-gathering method, which helped us understand the working processes in the supply chain by observing current working practices (see Appendix 1). We also conducted interviews with an RFID tag provider and a Finnish information system provider interested in developing RFID tracking in the case supply chain. To compare the results with existing RFID systems already in use, a benchmarking visit to the Dutch book retailer Selexyz was also conducted.

After these interviews and process observations had been undertaken, company representatives reviewed the findings and a workshop including all supply chain parties was held to discuss and validate the results.

As a result of the interviews, workshop, observing working procedures and examining the companies' processes, a supply chain-wide cost model of the investment needs and operating costs was made for different RFID implementation options. The model was built in MS Excel. The objective was to describe what benefits RFID technology would bring to the entire supply chain with the alternative implementation approaches.

The cost model was further developed to illustrate the effects of RFID implementation alternatives on costs and benefits to different parties in the case book supply chain. The model was built using activity-based costing (Cooper and Kaplan 1991) and typical components of investment cost-profit analysis (Drury 1996). The model had four different main parameter areas:

- (1) Existing information about supply chain companies' logistics operations and volumes. Here, the numbers corresponding to the unit costs of the technology, operating volumes of the companies, and estimations of the work needed to attach tags were filled out.
- (2) Estimations of fixed costs of building proposed RFID systems. Here, RFID equipment and software needs were noted for each supply chain member.

- (3) Calculations of variable annual costs of using the proposed RFID systems. Here, the model calculated the annual costs of the technology by using the unit costs from part 1 above and multiplying them by the values from part 2.
- (4) Calculations of the annual potential benefits of using the proposed RFID system. Here, the task-specific estimates regarding the potential savings of RFID technology were filled out for each supply chain member, and the model calculated the total benefits of the technology by taking into consideration the volumes and unit costs filled out in part 1, and the level of RFID equipment filled out in part 2.

The estimated values of the variables of the model came partly from the interviews and partly from the literature, and the values and the results of the models were compared with the results from a pilot by Selexyz, in The Netherlands, whenever possible. The results of the modelling were sent to the representatives of the project partner companies and later discussed together in a workshop to validate the values used and the results of the model.

The created cost model was further elaborated by including the financial effects of RFID technology for the different parts of the supply chain from a value chain analysis perspective (e.g. Dekker 2003). The starting point for the calculations was to index the current average retail price of the book that the consumer pays as 100. The next step was to divide this retail price between different members of the supply chain – publisher, author, printing house, LSP and bookstore – for the share that they will get for a sale of each book on average. In other words, this 100 is a sum of all supply chain parties' capitalised contribution for the book sold in a bookstore.

In the next step, each supply chain member's supposed costs of RFID tracking were added to the book retail price based on the premise that these costs increase the book retail price exactly by the value that can be calculated by dividing the costs by the total number of RFID tagged books that this particular supply chain member handles. Similar calculations were performed with respect to the supposed benefits of RFID tagging.

Finally, by adding costs and subtracting benefits for RFID tracking per book for each supply chain member's share of the retail price, it was possible to evaluate the financial effects of RFID tracking first for each specific supply chain member and then (by adding each member's values) for the whole supply chain. This calculated price, where the capitalised effects of RFID tracking are taken into account, is named 'scenario price'. The calculation of the scenario book price P_s can also be presented in the form of the following equation:

$$P_s = P_c * \left[1 - \frac{B - C}{N_b} \right],$$

where P_c = current book retail price, B = calculated benefits of RFID technology, C = calculated costs of RFID technology, and N_b = number of books circulating.

This model enabled the creation of different supply chain RFID tracking scenarios by calculating scenario prices for different tagging options. By comparing these different scenarios, it was possible to compare different postponement approaches with the speculative approach to attaching RFID tags. These results were validated in a workshop meeting in which supply chain parties participated to discuss and evaluate the results of the modelling of introducing RFID tracking in the case book supply chain.

4. Case findings: Finnish book supply chain

In Finland, bookstores have relatively high market shares in book retailing. It is estimated that 40% of books sold in Finland are sold in bookstores. This percentage varies, depending on the literary genres. The largest market share is for secondary education books, about 70% of which

are sold in bookstores. The smallest share is for encyclopaedias (5%). The bookstore's market share for other comparative literature is 55% (The Booksellers' Association of Finland 2008). The average retail price of all the books sold in Finland is about 15 euros. The writer's royalty is about 15% of the retail price; the publisher's share as a whole is about 25%; the share of book manufacturing is a bit below 20%, depending on the form of the book; logistics costs are about 5%; and value-added tax for books is 8% in Finland (Laurila 2005).

Currently, different titles are separated with different ISBN numbers in the book industry. Almost all of the books have an ISBN number, which is also printed on the book cover in the form of a barcode. That barcode is used widely in retailing. Different editions of the same title usually have the same ISBN number unless the cover form of the book is different or there have been considerable changes in the content between the editions (ISBN 2009). If RFID technology is used, all the books are additionally identified by an individual number.

Basically, there are three possible supply chain echelons to attach an RFID-tag for books: (1) in the manufacturing phase at the printing house, (2) in the LSP's facilities, or (3) in the book retailer's facilities.

These options are also interconnected, in that, by selecting the printing house alternative as the primary place for attaching RFID tags, some tagging will also occur in the LSP facilities and even in the bookstores. Books arrive from around the world to the LSP, and it will take a long time (if ever) before all of them can be equipped with RFID tags in the manufacturing phase. But even if all the books are tagged at the LSP, there will likely remain a need to tag some books in the bookstore, because sometimes single bookstores order individual books directly from the publisher or a foreign wholesaler, or the customer may want to return or exchange a book, in which the RFID-tag has been removed. Figure 1 shows a model of the book supply chain, where the alternative supply chain echelons to attach RFID tags are marked with a circle, and flows of RFID-tagged books are marked with grey arrows. In addition to the case book supply chain participants, Figure 1 also shows the most important book flows to and from the other actors of the industry.

The advantage in the first alternative, attaching RFID tags in the printing house during the manufacturing phase, is that, the cost of attaching each tag is low, because the attaching can be done automatically. The quality of tagging is also best in this part of the supply chain, because

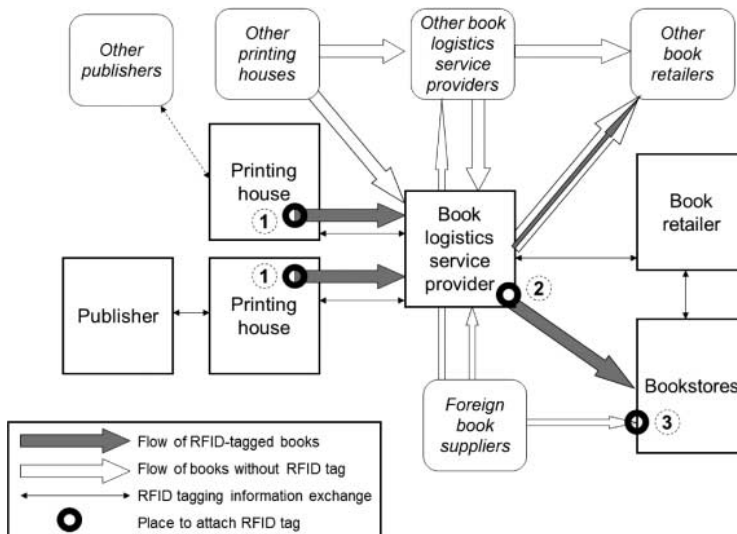


Figure 1. Supply chain model, where books are RFID-tagged as early as possible in the supply chain.

the tag can be placed inside the book easily without risk of damaging the book, which becomes a problem when the books are tagged in the later parts of the supply chain. A major problem in this phase, is that, at least in the beginning, most of the tags end up with retailers who are not able to use these tags. Tagging only parts of the edition would be too complicated and expensive, according to the assessment of experts from the printing industry, and therefore if tagging is done in this phase, it is speculative.

The second alternative, postponed tagging in the LSP facilities has basically two different options: Either tag all incoming books or tag those books which are dispatched to those particular retailers who can use these tags. Currently, the LSP is adding barcodes for all those incoming books which do not have printed barcodes. However, when the issue is about RFID tags, many books are destined for retailers who are not able to use these tags. Tagging is now postponed to when picking and packing the orders of customers that can use the tags. The benefit of this alternative is that every attached tag will be used – at least in the retailer's receiving process. However, these tags will probably have to be attached manually, as is done currently at Centraal Boekhuis in the Netherlands. Therefore, the attaching cost per tag is much higher than in the printing house alternative.

The third alternative, postponement of attaching the RFID tags in the retailers' stores, could be the easiest from the business point of view because the tags will be used only inside one company. However, this alternative has other features that do not favour this option. One of the main benefits of RFID tagging books is the faster receiving process in bookstores (Kroon *et al.* 2007), but tagging the books in the bookstore slows down the receiving process and requires extra space. Attaching the tags at the retailer, especially in small-volume bookstores, is probably slower and costlier than attaching them in the LSP facilities.

4.1. *Cost-benefit calculations*

Detailed calculations of the financial impact of RFID tracking for different tagging location alternatives were made and verified in the workshop. The costs were divided into fixed investment costs and variable costs such as tagging, software licence fees and maintenance costs of new equipment involved in RFID technology. The total benefits were calculated by adding different observed benefits together. The parameters used to calculate the benefits were evaluated in a conservative way, because the intention was to avoid overestimating the potential benefits of RFID technology. The only included benefit of the technology, which may be difficult to reach in some cases, was increased sales in bookstores. This was estimated to be about 10% mainly due to reduced out-of-stocks and misplaced books.

At first, the financial effects of RFID tracking were analysed at a detailed level for the different parts of the supply chain without considering the investment costs. The average retail price of a book was divided between different supply chain parties, according to their shares of the book retail price as presented in the end of the first paragraph of Section 4. The scenario prices were calculated by dividing the difference between the estimated benefits and costs with the number of books that would be handled in that part of the supply chain, and then subtracting this quotient from the current book retail price as described at the end of the Methodology section.

Books can be tagged in many echelons in the supply chain: speculatively in the printing house, postponed at the LSP facilities, or even in the bookstore. Therefore, for the case supply chain, three different scenario prices were calculated. Table 1 presents the current cost division of the book and three different scenario prices for the book dependent on the place where the book is tagged. The current book retail price is indexed to be 100.00 in the table in order to simplify the comparisons. The investment costs are not taken into consideration in Table 1.

Table 1. The division of book price with different scenarios if the investment costs are not taken into consideration.

	At the moment No RFID tag	RFID tagged book without investment costs		
		Tagged in printing house	Tagged by LSP	Tagged by bookstore
Scenario price of the book	100.00	95.53	94.70	96.93
Value added tax	7.41	7.08	7.02	7.18
Royalty	15.00	15.00	15.00	15.00
Publisher's share	25.00	23.77	25.00	25.00
Printing house's share	18.00	21.73	18.00	18.00
Logistics	5.00	4.58	6.32	5.00
Bookstore's share	29.59	23.37	23.37	26.75

The assumption made in Table 1 was that if the downstream supply chain member tags the book, it has no effect on the actual price value of upstream supply chain members. If the book is speculatively tagged in the printing house, the publisher gets some benefits of increased visibility. The printing house would also get some benefits, even if these are not taken into consideration in the model. At any rate, in the model, the cost of all tagged books goes to the printing house, even those 80% of books in the model end up at retailers who are not able to capitalise on the benefits of the RFID tags. Therefore, the cost share of the printing house increases considerably, if the books are speculatively tagged in the printing house. In addition, the LSP can improve its operations when handling the books with RFID tags, and the savings of the LSP are much higher if the book has speculatively been tagged in the printing house.

If the book tagging is postponed to the LSP facilities, its share of the retail price of the book is much higher than it is at the moment or in the case where the book has speculatively been tagged in the printing house. For a bookstore, there is no difference from a cost–benefit point of view whether the book is tagged in the printing house or in the LSP facilities: the retailer will still obtain all the calculated benefits of RFID technology.

If the tagging is postponed to the bookstore, it has no effect for the other supply chain members' price values. In this scenario, the bookstore will get its benefits only partially, and all the tagging costs will be directed to the bookstore. It is also estimated in all scenarios that RFID tagging has no effect on royalties.

Table 1 shows a clear potential for reducing the costs in the book supply chain through RFID tracking. It also shows that tagging in the bookstore is more expensive than in the other two options. In the case supply chain, it seems to be more expensive to speculatively tag the book in the printing house than postpone it to the LSP facilities, but the cost difference between these options is moderate.

4.2. Cost and benefits of RFID tagging for supply chain parties in more detail

Taking into account both the cost and benefit of postponement versus speculation of RFID tagging, the model indicates that the case printing houses should tag all the books they publish for Finnish markets. In practice, this means that in the model 40% of all the books in Finnish markets are tagged while they are in the printing house phase, and other titles and editions printed elsewhere are speculatively tagged when they leave the LSP facilities and head to the project participant's bookstores. It was also estimated that each bookstore's own tagging would only cover about 2% of all the books sold in these stores.

It was estimated that all the participating companies would require considerable investments for their information systems, because item-level RFID tagging expands the need to store and

transmit information. Also, investments in RFID infrastructure, including equipment for RFID tagging, reading and deployment in customer service in bookstores are needed.

The biggest single cost factor among all the calculations is the cost of the RFID tags and the tag attachment costs. The tag provider company estimated that the cost for suitable tags would be about €0.10 apiece, which alone would increase the indexed price of the book by 0.67. It was also estimated that attaching the tag in the printing house would cost about 0.07 of the indexed retail price per tag, 0.67 per tag if postponed to the LSP facilities, and 1.34 per tag when tagging is postponed to the bookstore. The tagging cost in the LSP facilities in the model is about the same as Selexyz pays Centraal Boekhuis for attaching RFID tags, but the other costs are based only on estimations made with industry experts.

The potential benefit of RFID tagging in the early phase of the supply chain is that all the supply chain members could exploit the same RFID tag in their operations. Publishers get benefits when they have better visibility of their product movements and stock levels. Current ISBN-numbering-based warehouse management systems (WMS) do not usually separate different editions of the same book, for instance. However, knowledge of the stock levels of different editions may be very important for the publisher when planning the schedule for new editions, for example, for school books in which old editions are dismissed by students.

Printing houses get benefits from item-level RFID tagging if mistakes that require book recalls occur. In that case, the printing house is likely able to restrict the faulty books at least to the edition level. With RFID reading of tagged books, it is possible to find the faulty books quite rapidly without manually inspecting all the books.

The benefits for LSPs depend on the amount of speculatively RFID-tagged books that arrive at their facilities. If the books already have an RFID tag when they arrive, the receiving process is considerably faster than for books without RFID tags. Also, stock-taking is faster if some of the titles have RFID-tags when in the LSP warehouse. When RFID-tags are in every book that is shipped to RFID bookstores, the LSP can automatically check the outgoing shipments against picking errors.

As we learned in the interviews, the bookstore is estimated to reap the biggest benefits from RFID technology deployment in the case supply chain. The experts estimated that the benefits come primarily from increased sales, and secondly from the faster receipt of shipments, which also decreases the backroom space needed in bookstores. The third considerable benefit for bookstores was estimated to be faster, more streamlined stock-taking. The big benefits for the retailer are in line with the literature. This can be compared with the Selexyz implementation, where the biggest benefit was also increased sales. In the Selexyz implementation, the bigger sales in RFID-enabled bookstores were estimated to come from better availability of books, more flexible book-ordering systems and faster searching for books on shelves according to the interviews. Moreover, the representatives from the case supply chain believed that they could use RFID tracking to offer some value-added services to customers in order to increase sales. Selexyz also realised the other estimated benefits. Before moving to RFID technology, it took, several Selexyz workers, three days to conduct an annual inventory for the Almere bookstore. Today, it takes from 1 to 2 h for one worker to perform similar stock-taking. In addition, some improvements to other processes such as shelving will provide savings after moving to RFID technology.

All the measurable benefits, which were considered in the model are summarised in Table 2. Table 2 also presents the calculated values of these benefits for each supply chain partner. However, all the benefits are fully applicable only in the 'speculative tagging in printing house' scenario, while for other scenarios, the applicability of the benefits depends on whether the book is already tagged at the point in question. In addition, the costs of RFID tagging are not subtracted from the values, and therefore the values presented in Table 2 could be used to compare different benefits with each other, or to adjust the figures in Table 1 if some of the presented benefits seem over- or under-rated. There are also some other benefits that were recognised (marked in italics), for

Table 2. The summary of measurable benefits of RFID tracking and their price decreasing effects as a percentage of current book retail prices for different supply chain members in the speculative tagging scenario.

Publisher	Printing house	Book LSP	Bookstore
Increased sales (1.32)	<i>Better quality control</i> (not modelled)	Faster stock-taking (0.03)	Increased sales (2.86)
Fewer problems when defining royalty (0.01)	<i>Faster to solve quality problems</i> (not modelled)	Fewer mistakes in shipping (0.07)	Decreased need for backroom space (0.91)
<i>Better information about the demand of different labels and editions</i> (not modelled)	<i>Value-added services provided by the printing house</i> (not modelled)	Faster handling of returned books (0.09)	Decreased time needed for daily duties (e.g. receiving shipments, stock-taking, shelving, cashier work, re-pricing) (1.14)
<i>Value-added services provided by publisher and printing house</i> (not modelled)		Faster receipt of shipments from the printing house (0.24)	Better availability of books and customer service (0.86)
			Decreased theft (0.31)
			More efficient returning of books to LSP (0.13)

which we were not able to obtain a quantified value. Therefore, these factors are not taken into account in the model.

However, even though the transition to RFID tracking in the case of the supply chain is intended to be permanent and the model has calculated various annual maintenance and updating costs for the technology, the transition to RFID tracking requires a considerable amount of money for investments. The cost model enabled us to create similar tables to Table 1, but taking into consideration investment costs depending on various different assumed amortisation periods. In Figure 2, the investment costs are added to the scenario prices of the book presented in Table 1 to show the magnitude of the investments needed to implement RFID tracking in the case book supply chain. The scenario prices in different RFID tracking scenarios are presented with amortisation times between 1 and 10 years, if the effect of interest is not taken into consideration.

Figure 2 shows that speculative tagging requires proportionally bigger investments, and therefore, if a short investment amortisation period is imposed, postponed tracking becomes more attractive.

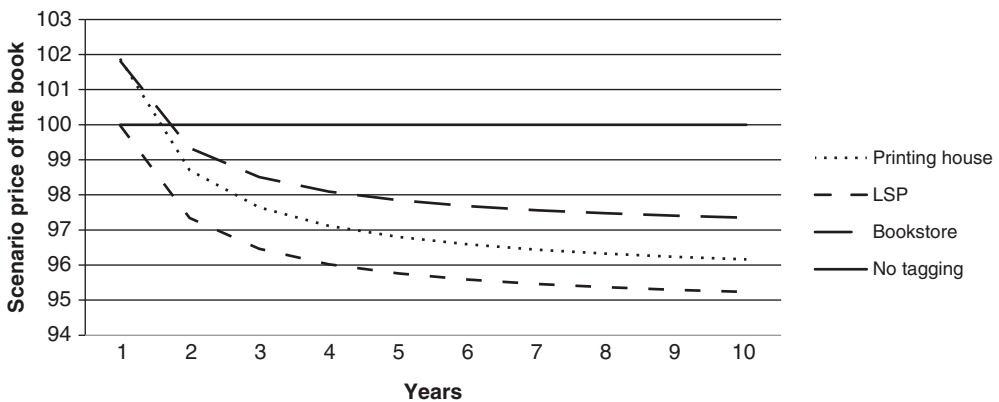


Figure 2. The impact of amortisation time on the different RFID tracking scenarios.

The practical outcome of the investment analysis for the case supply chain is that, if the case companies (publisher, two printing houses, book LSP and the bookstore chain, with all 63 bookstores) begin to use RFID technology simultaneously and at the scale previously described at the beginning of Section 4.2, the break-even point at which the accumulated benefits become bigger than the costs incurred at a whole supply chain level would be about 15 months after implementing the system, according to the model we have proposed.

The break-even point was calculated by adding all the costs and benefits of all the companies together. If companies concentrate only on their own costs and benefits when implementing the proposed system, the retailer would have considerably lower break-even points while for printing houses, the costs would be infinite, because no benefits were identified for them. Therefore, to be able to continue the dialogue towards implementation of this potential solution, there is no case for discussing break-even points for single companies.

4.3. Sensitive analysis of results and cost-benefit calculations

While Table 1 shows that the tagging is cheapest when performed at the LSP with the market shares used in the modelling, a sensitivity analysis was conducted to evaluate the threshold level of end-users at which it starts to make sense to attach RFID tags speculatively in the printing house. Figure 3 presents the results of this analysis, and shows when more than 27% of books end up with a retailer that can use RFID technology, it is cheaper to tag the book speculatively in the printing house, assuming total investment costs are similar in the different scenarios (which in our analysis was considered appropriate as at least 93% of required investments do not vary between scenarios).

If the bookstore chain participating in the case supply chain will deploy RFID technology as a whole, as modelled, it will sell about 20% of all books sold in Finland. This amount is quite close to the calculated break-even percentage. When a publisher designs the book, it will also make estimations regarding where the book will be primarily sold, and it will also make agreements with retailers. So, from the publisher's or bookstore's viewpoint, there is no need to track encyclopaedias, for example, because these books seldom end up in any bookstore. Such books need not be considered. The majority of the books in bookstores belong to other comparative literature – 55% of the books in this genre are sold in bookstores. If half of them, as an average,

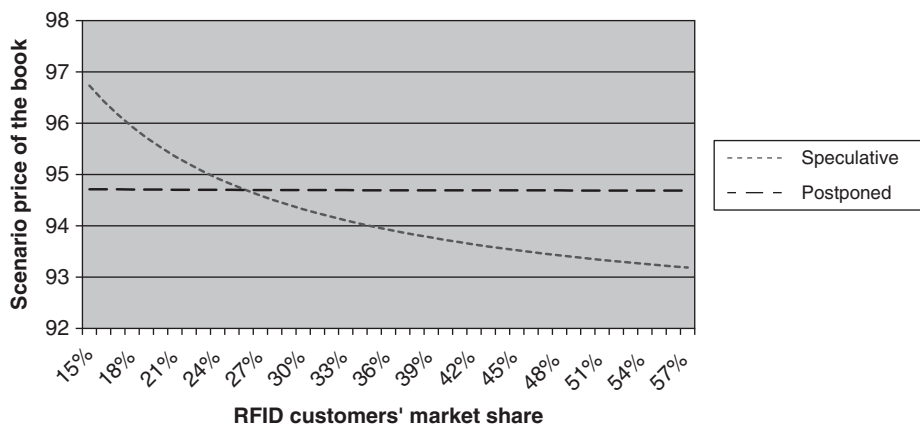


Figure 3. The comparison of book price between attaching RFID tags speculatively in the manufacturing phase and postponing it to the book LSP (assuming similar technology investment costs).

are sold in the case bookstore chain's stores, there is barely any cost difference from the supply chain point of view as to whether the books are speculatively tagged in the printing house or tagging is postponed to the LSP facilities.

There are also some trends that favour speculative tagging in the printing house, if there is no significant cost difference between these two options. First, the cost of RFID tags will probably decrease in the future. If the cost of the tag decreases 30% from the cost used in the calculations, the scenario price for a book in Table 1 would be 94.47 for both the printing house and LSP tagging alternatives. Second, the cost of the workforce will probably also increase, which has a tiny effect for the tagging costs in the printing house, but a major effect on the LSP's tagging costs. Third, the calculations used did not count any benefits of the technology for the printing house because there was no information on the frequency of the printing house's quality problems. If these problems exist, or there will be other reasons to recall books, the RFID technology deployed already in the printing house will reduce these costs considerably. Fourth, the assumption in the calculations was that the technology is not developed enough to read all the tags of a pallet of books at once. When RFID technology has matured to that level, even higher cost savings will emerge, especially in the logistics costs between the printing house and the LSP. Fifth, the printing house is able to attach the tag inside the book, which is not possible in later parts of the supply chain. If the retailer or end-user has added value of this more durable tag, such as using the tag as an anti-theft alarm or developing after sales services or markets for the book, there will also be additional reasons that favour speculative tagging in the printing house.

Because RFID technology considerably decreases the costs related to book retailing, and the experiences at Selexyz and Byblos are encouraging, it is expected that other bookstores in Finland would be interested in deploying RFID tracking in their operations. In addition, RFID tracking is already being used in one of the major libraries in Finland, with favourable results, and other libraries have also researched possibilities to deploy the technology. Therefore, it is estimated that the percentage of printed books ending up with a retailer or other end-user who is able to use RFID tags will increase. This also means that speculative tagging in the printing house is an option that should be taken into consideration when designing RFID systems for book supply chains. Some need for postponed tagging will still remain, however. Some books are still printed without barcodes, and unless the diffusion of RFID tagging is much quicker than expected, then either the LSP or the individual bookstores will need to attach the missing tag in the same way as they attach missing barcodes today.

5. Conclusion

Introducing RFID tracking at the item-level in the book supply chain can be described as a problem of moving from postponement to speculation in the design of the tracking solution. Initially, only the books going to customers who are able to use RFID tracking are tagged. But as the use of RFID tracking becomes more prevalent amongst retailers, speculative tagging of all the books will gradually become more economic. Once a threshold level is reached, the postponement of RFID tag attachment will become economically wasteful from a supply chain perspective. Switching to speculative RFID tagging means that the same tag can be used multiple times by several different supply chain members without increasing the cost of currently used RFID systems that are built to solve a limited number of problems for an individual supply chain member. In the supply chain investigated in this paper, the analysis model that has been developed has shown that once about one in four books are sold by those retailers that use RFID tracking, attaching RFID tags anywhere else than in the manufacturing phase is not justified. Even if this percentage varies in different supply chains, it remains so low that the question regarding speculative tagging becomes relevant for many other supply chains, where retailers interested in implementing RFID as a group have

a reasonable market share of some manufacturer's product. Even where the speculative tagging option would not be considered when designing an RFID system at present, the situation may change when other retailers become interested in RFID tracking. Therefore, systems should be designed from the outset either so that they will be open to other parts of the supply chain who could easily join the same system, or else that the system could be included as part of a bigger future system.

This paper has focused on analysing the rather easily capitalised costs and benefits of RFID tracking. However, RFID tracking increases supply chain visibility between the companies if applied correctly. This improved supply chain visibility can be utilised as faster delivery times, fewer out-of-stock situations, offering additional services to customers, etc. The more upstream the point at which the RFID tag is attached, the better are the possibilities to change the whole supply chain to become more agile and customer-oriented. Therefore, speculative tagging could be economically justified with even a smaller share of RFID end-users. One future research area is in studying and quantifying these inter-organisational benefits more in detail.

However, even though the model presented in this paper indicates that the costs might be lower if the books are tagged in the printing house than if they are tagged at the LSP, there are practical problems that must be solved before a speculative design of RFID tracking is feasible. Attaching tags in the bookstore or in the facilities of the LSP is relatively easy from a cost allocation point of view. If the bookstore is not attaching the tag itself, it can ask the LSP to provide this extra service with relatively low investment costs, and the bookstore pays for that service. This paper has not dealt with the division of costs between retailers who are able to benefit from RFID tagging and those that are not able to. It is problematic to charge all retailers a higher price for RFID tagged books, but it is also problematic to only charge retailers that use RFID tracking a higher price. This question about division of cost and benefits requires more research.

To share tagging costs, a further possibility is for the publisher and printing house to develop a solution requiring authorised activation of tags. This would enable the printing house or publisher to directly charge other supply chain parties interested in using RFID on speculatively tagged books.

Despite the undeniable advantages of supply chain-wide RFID tracking when performed on a sufficiently large scale, to our knowledge the actual implementation and piloting of it for the book supply chain has not yet been undertaken. The real business, organisational and other reasons for not implementing RFID tracking remain to be clarified. Identifying those reasons and determining how to resolve the remaining challenges is an interesting question for further research.

References

- Ala-Risku, T., Kärkkäinen, M., and Holmström, J., 2003. Evaluating the applicability of merge-in-transit. *International Journal of Logistics Management*, 14 (2), 67–81.
- Attaran, M., 2007. RFID: an enabler of supply chain operations. *Supply Chain Management: An international Journal*, 12 (4), 249–257.
- Bertrand, W. and Fransoo, J., 2002. Operations management research methodologies using quantitative modeling. *International Journal of Operations & Production Management*, 22 (2), 241–264.
- Boone, C., Craighead, C., and Hanna, J., 2007. Postponement: an evolving supply chain concept. *International Journal of Physical Distribution & Logistics Management*, 37 (8), 594–611.
- Bucklin, L., 1965. Postponement, speculation and the structure of distribution channels. *Journal of Marketing Research*, 2 (1), 26–31.
- Christopher, M., 1998. *Logistics and supply chain management: strategies for reducing cost and improving service*. 2nd ed. London: Financial Times/Pitman.
- Cooper, R. and Kaplan, R., 1991. Profit priorities from activity-based costing. *Harvard Business Review*, 69 (3), 130–135.
- Curtin, J., Kauffman, R., and Riggins, F., 2007. Making the 'MOST' out of RFID technology: a research agenda for the study of the adoption, usage and impact of RFID. *Information Technology and Management*, 8 (2), 87–110.

- Dekker, H., 2003. Value chain analysis in interfirm relationships: a field study. *Management Accounting Research*, 14 (1), 1–23.
- Drury, C., 1996. *Management and cost accounting*. 4th ed. London: International Thomson Business Press.
- Hadfield, W., 2006. Bookseller scores a first with RFID move. *Computer Weekly*, 2 May, p. 6.
- Holmström, J., Tenhiälä, A., and Kärkkäinen, M., 2011. Item dwell time in project inventories: a field experiment. *Computers in Industry*, 62 (1), 99–106.
- Hou, J.-L. and Huang, C.-H., 2006. Quantitative performance evaluation of RFID applications in the supply chain of the printing industry. *Industrial Management & Data Systems*, 106 (1), 96–120.
- ISBN, 2009. Available from: <http://www.isbn.org/standards/home/index.asp> [Accessed 2 May 2009].
- IT Reseller Magazine, 2008. Byblos applies Avery Dennison RFID tag system to reduce 30 per cent in stock and 65 per cent wait time in cash desks and inventory. *IT Reseller Magazine*, 21 July.
- Kärkkäinen, M. and Holmström, J., 2002. Wireless product identification: enabler for handling efficiency, customization and information sharing. *Supply Chain Management: An International Journal*, 7 (4), 242–252.
- Kärkkäinen, M., Ala-Risku, T., and Främling, K., 2004. Efficient tracking for short-term multi-company networks. *International Journal of Physical Distribution & Logistics Management*, 34 (7), 545–564.
- Kroon, J., et al., 2007. RFID in retail: new approaches, new viewpoints. *European Retail Digest* [online], (55), 33–39. Available from: Business Source Complete, EBSCOhost [Accessed 20 March 2012].
- Laurila, A.-L., 2005. *Bittejä paperilla. Kirjan hinta ja kaunokirjallisuuden murros 2000-luvun alussa*. Master's thesis in Finnish literature. Tampere University.
- Lin, C.-Y. and Ho, Y.-H., 2009. RFID technology adoption and supply chain performance: an empirical study in China's logistics industry. *Supply Chain Management: An International Journal*, 14 (5), 369–378.
- Loebbecke, C. and Huyskens, C., 2008. Item-level RFID in the Japanese publishing industry: a case study. *The Communications of the Association for Information Systems (CAIS)*, 23 (1), 319–332.
- Loebbecke, C. and Powell, P., 1998. Competitive advantage from IT in logistics: the integrated transport tracking system. *International Journal of Information Management*, 18 (1), 17–27.
- Martinez-Sala, A., et al., 2009. Tracking of returnable packaging and transport units with active RFID in the grocery supply chain. *Computers in Industry*, 60 (3), 161–171.
- Pagh, J. and Cooper, M., 1998. Supply chain postponement and speculation strategies: how to choose the right strategy. *Journal of Business Logistics*, 19 (2), 13–33.
- Rekik, Y., et al., 2007. Improving the performance of retail stores subject to execution errors: coordination versus RFID technology. *OR Spectrum*, 29 (4), 597–626.
- Schonfeld, E., 2006. Tagged for a growth. *Business 2.0*, 7 (11), p. 58.
- Smart, A., Bunduchi, R., and Gerst, M., 2010. The costs of adoption of RFID technologies in supply networks. *International Journal of Operations & Production Management*, 30 (4), 423–447.
- Soon, C.-B. and Gutiérrez, J., 2008. Effects of the RFID mandate on supply chain management. *Journal of Theoretical and Applied Electronic Commerce Research*, 3 (1), 81–91.
- Spekman, R. and Sweeney, P., 2006. RFID: from concept to implementation. *International Journal of Physical Distribution & Logistics Management*, 36 (10), 736–754.
- Stefansson, G. and Tilanus, B., 2001. Tracking and tracing: principles and practice. *International Journal of Services Technology and Management*, 2 (3/4), 187–206.
- Swedberg, C., 2008. Portuguese book megastore deploys item-level RFID system. *RFID Journal*, 17 January.
- Swedberg, C., 2009. Japanese publisher sees RFID as a cure for overstocks. *RFID Journal*, 5 January.
- The Booksellers' Association of Finland, 2008. *Kirjamynttilästatot* [online]. Available from: <http://www.kirjakauppaliitto.fi> [Accessed 2 September 2008].
- Trebilcock, B., 2006. The book on item-level RFID tagging. *Modern Materials Handling*, 61 (6), 43–45.
- Twist, D., 2004. The impact of radio frequency identification on supply chain facilities. *Journal of Facilities Management*, 3 (3), 226–239.
- Van Hoek, R., 2001. The rediscovery of postponement: a literature review and directions for research. *Journal of Operations Management*, 19 (2), 161–184.
- Vijayaraman, B. and Osyk, B., 2006. An empirical study of RFID implementation in the warehousing industry. *The International Journal of Logistics Management*, 17 (1), 6–20.
- Visich, J., et al., 2009. Empirical evidence of RFID impacts on supply chain performance. *International Journal of Operations & Production Management*, 29 (12), 1290–1315.
- Whang, S., 2010. Timing of RFID adoption in a supply chain. *Management Science*, 56 (2), 343–355.
- White, A., Johnson, M., and Wilson, H., 2008. RFID in the supply chain: lessons from European early adopters. *International Journal of Physical Distribution & Logistics Management*, 38 (2), 88–107.
- Wong, C. and McFarlane, D., 2007. Radio frequency identification data capture and its impact on shelf replenishment. *International Journal of Logistics: Research and Applications*, 10 (1), 71–93.
- Yang, B., Burns, N., and Backhouse, C., 2004a. Management of uncertainty through postponement. *International Journal of Production Research*, 42 (6), 1049–1064.
- Yang, B., Burns, N., and Backhouse, C., 2004b. Postponement: a review and an integrated framework. *International Journal of Operations & Production Management*, 24 (5), 468–487.
- Yeung, J., et al., 2007. Postponement strategy from a supply chain perspective: cases from China. *International Journal of Physical Distribution & Logistics Management*, 37 (4), 331–356.
- Yin, R., 1994. *Case study research: design and methods*. 2nd ed. Thousand Oaks, CA: Sage.

Appendix 1. Interview and observation guide

Discussion topics with the book supply chain companies

How many pallets/boxes/books does the company/unit manufacture/handle in an average day/week/month/year? Where do they come from and where they are going? What is an average size (number of books and SKUs) of the incoming/outgoing shipment?

Does the company already have process charts about the physical processes and information flows?

Discussion about the information system that the company currently has. Are there any improvement needs/efforts at the moment?

Discussion about the tasks that need a lot of manual work. What are these? Are there any estimations of the amount of the time used in these tasks? Are there any problems when performing these tasks? Any efforts to improve the situation?

Discussion about tracking systems and information exchange between supply chain partners. Current tracking systems? Information exchange between companies? The main problems?

How does the company see the relationships between book supply chain members?

Discussion about the costs and benefits that RFID technology may bring to the company. Trying to obtain the companies' own calculations/estimations about the current time needed for the process phases of interest. Trying also to get some figures about current problems in processes (amount of lost/stolen books, errors in shipments, inventory errors, availability problems, etc.).

Observation issues

Printing house

Familiarizing oneself with all the processes of the printing house including going through the manufacturing phases for different forms of the books (bound, stapled, hard cover, soft cover).

Determining together with printing house managers and workers the most appropriate phase in the binding/stapling processes to attach the RFID tag to the book and add the information to that tag.

Discussion of the installation cost of automatic RFID tag attachment. Estimations of the manual work needed in different phases when implementing RFID technology.

Book LSP and book retailer

Observing the processes in the facilities of the book LSP (receiving, shelving, stock-taking, picking and packaging orders) and in the bookshop (reception and acceptance of incoming shipments, shelving, stock-taking, searching the books from shelves, selling).

- Write down everything that takes place in current routines;
- Measure the time needed to undertake these routines;
- Identifying possible places where mistakes can be made;
- Estimating how RFID technology can change and improve these operations, and identifying any parts of existing routines that will no longer be needed when RFID technology is in use.