A Cost-Benefit Calculator for RFID Implementations in the Apparel Retail Industry

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ABSTRACT

The apparel retail industry is on the one hand facing challenges from increasing competition, consolidations, and thus increasing pressure to reduce costs. On the other hand, customers are getting more demanding, resulting in shorter fashion cycles, and demands for new customer experience. RFID technology is supposed to raise efficiency and to enable innovative customer service offerings. Besides cost savings, benefits are expected to arise from newly designed RFID applications and customer insights from analyses of shop floor data. Recently, apparel retailers started to investigate this technology, resulting in several trials and pilots world-wide. However, the business case of RFID in the apparel retail industry is not clear. Based on the findings of a real-world deployment, our contribution presents a cost-benefit calculator that is specifically designed to meet the requirements of apparel retail industry RFID implementations.

Keywords

RFID, ROI Estimations, Cost-Benefit Calculator, IT Value, Apparel Retail Industry.

INTRODUCTION

Problem Statement

The apparel retail industry is characterized by the management of a wide assortment of products, short life-cycles, high seasonality, high volatility, high-impulse purchasing, and complicated distribution and logistics operations (Christopher, Lowson and Peck, 2004). Thus, the benefits of RFID technology seem to be particularly apparent in fashion retailing (Moon and Ngai, 2008). Industry organizations also support this view, stating that RFID technology may help fashion retailers solve a number of problems that are unique to their industry (IDTechEx, 2005). These challenges encompass (i) short product lives of fashion products (typically only about three months), (ii) complexity of product management, due to a high variety of apparel product characteristics, (iii) product counterfeiting in the supply chain, and (iv) lack of knowledge about behavior of fashion shoppers, yet considered to be "mysterious and unpredictable" (Moon and Ngai, 2008). Moreover, consumers are more demanding and their behavior has become increasingly difficult to assess (Gagnon and Chu, 2005). Several aspects complicate the understanding of consumer behavior. First of all, there is an increased diversity of customer groups. This is due to the fact that long-standing life-patterns have become less predictable. For example, people tend to marry later, divorces are increasing, they start new careers, and move to new locations more often than in the past (Gagnon and Chu, 2005). Furthermore, the ageing of populations in Western countries forces retailers to consider the special needs of elderly people. At the same time, ethnic diversity in Western countries has increased during the last decades. Those demographic changes have contributed to shifts in decision patterns of consumers (Samli, 2004).

Consequently, retailers are looking for new ways to offer enhanced shopping experiences to demanding customers, and RFID technology is supposed to help attaining this goal. Specific applications, such as digital shopping assistants and smart fitting rooms, do not only offer product information, but also have the potential to strengthen the interaction with customers by presenting real-time marketing messages and digital media for entertainment (Thiesse, Wiechert and Tellkamp, 2007).

Additionally, RFID data gathered through logging the routes of products and customers on the store floor allows for a deeper understanding of customer behavior, which lays the foundation for an improvement of store layouts, product assortments, the checkout process, inventory taking, the management of sales personnel, merchandise performance, category management, reordering, purchasing, shelf replenishment, and inventory level controls. An RFID-based stock management system can identify the needed items for the customer quickly and correctly, and consequently "search regret" may be minimized (Reynolds, Folse and Jones, 2006). In addition, RFID data analyses of customer behavior promise to offer new ways for apparel retailers to understand better and react more quickly on consumer perceptions and to enable them to offer customized marketing programs for their loyal customers (Li and Visich, 2006). However, this is an under-researched area (Moon and Ngai, 2008).

The adoption of RFID is not always voluntary though: some retailers such as Wal-Mart and Target decided to issue large scale mandates that gave major suppliers deadlines, after which the retailers would refuse to accept non RFID tagged deliveries. Moreover, there is some indication that the initial enthusiasm around RFID has at least partly given way to a more disillusioned assessment (Lacy, 2005; The Economist, 2007). Often voiced barriers include unclear benefits, prohibitive technology costs, and questions of cost sharing among supply chain partners. Besides economic aspects, an additional issue has evolved in the form of massive consumer concerns with regards to the perception of RFID as a risk to privacy (Gunther and Spiekermann, 2005; Thiesse, 2007). Therefore, holistic business case considerations are becoming extremely important. Against this background, this paper introduces a flexible, extensible RFID business case calculator tool that has successfully supported the business case assessment of a real-world RFID deployment in the apparel retail industry.

Objective and Structure

The retail department store sales floor is a particularly complex deployment setting for RFID implementations. This is because a full deployment requires RFID monitoring in fitting rooms, on elevators, escalators, warehouses, checkouts, shelves, in customer applications such as recommender systems, or information kiosks, just to mention some. In other words, such an implementation can be regarded as an "in-door" supply chain itself. To illustrate the complexity of such an environment, we provide the details of the real-world RFID implementation in a department store, which our findings are based on.

The goal of the retailer under study was to examine the degree to which RFID could increase the level of inventory, improve department store logistics and processes, increase sales, and identify new fields of application. On the sales floor, approximately 30,000 individual RFID-equipped apparel items are constantly available. These are seamlessly tracked on item-level on their way from the distribution center to the point of sale. In total, the infrastructure includes 64 RFID readers and 208 antennas. Some RFID readers are additionally equipped with photoelectric barriers and motion detectors in order to determine the direction of the flow of goods. With every movement of products captured by the readers, RFID events are generated and stored in the company's "EPC Information Service (EPCIS)" (EPCglobal, 2007), a repository for the collection and sharing of RFID data.

Prior research has developed business case calculators that assess benefits of RFID in extended supply chains (i.e. from the manufacturer to the retailer) in the grocery industry, primarily focusing on the logistical part of the supply chain (Tellkamp, 2003; Lee, Peleg, Rajwat, Sarma and Subirana, 2004; Vogell, 2005; Leung, Cheng, Lee and Hennessy, 2006).

In contrast to that, our contribution concentrates on the benefits of an RFID implementation in the apparel retail industry. More precisely, we present a cost-benefit calculator that is specifically designed to meet the requirements of RFID implementations in stores. In such a domain, benefits not only include savings from higher operational efficiency, i.e., cost cuttings due to time or labor savings, but encompass additional revenues from RFID consumer applications (like Recommender Systems, installed in fitting rooms or Intelligent Shelves), improved shop floor layout, optimized product assortment and inventory levels.

The remainder of this paper is structured as follows. Section 2 (Fundamentals) describes the ground rules of a business case analysis, provides a business case structure, and gives an overview of existing calculators. Specific requirements and the conceptual approach of the presented business case tool and its validation are presented and discussed in Section 3 (Overview of the apparel retail Business Case Tool). Finally, the Summary and Outlook Section provides a conclusion, a discussion of limitations, and opportunities for further research.

FUNDAMENTALS

Business Case Analysis

According to Prest and Turvey (1965), the aim of a cost-benefit analysis is to "maximise the present value of all benefits less that of all costs, subject to specified constraints". A business case methodology is a tool that supports planning and decision-making when considering investments. Thus, business cases are generally designed to answer the following question: what are the likely financial and other business consequences if the management chooses a specific action (Schmidt, 2003)? It is the aim of every business case to highlight the proposal that represents the best business decision. This aim can only be achieved if the business case is based on a sound logical structure. The logical structure of the case resides in the scenario design, the cost model, and the benefit rationale. The term 'scenario' itself is defined as a snapshot or a process describing one way that events might develop in the future (Schmidt, 2002). Therefore, it is the purpose of this specific scenario model to combine various retail-related, as well as RFID-related aspects into a full list of necessary investments. Specifying a list of all investments is essential for calculating the realistic financial impact, which is an important basis for decision-making. Project leaders use business case analysis as a means to convince top management of the necessity of investments. Furthermore, such a tool is important to show the expected results of a project, e.g. in terms of financial returns (Brugger, 2005).

Further advantages of a business case include:

- **Transparency**: A good business case shows expected cash flow consequences of the action over time, and most importantly, also includes the methods and rationale that were used for quantifying benefits and costs (Schmidt, 2003).
- **Certainty in decision-making**: In complex business environments every decision-making process is associated with uncertainty. A business case contributes to reducing this uncertainty by offering tangible results in a transparent procedure. It furthermore evaluates a project by examining different scenarios, which enables the comparison of different outcomes of a specific challenge and assists in deciding which scenario is best (Brugger, 2005).
- **Improvement of the project**: A business case does not only help to evaluate a project and find the right alternatives, but also assists in improving the project itself. The necessary deep understanding of the issues enables the detection of weak spots in the project before its implementation. As the business case offers financial information on benefit potentials, these potentials can be optimized in order to meet expectations, particularly with regard to business success. Therefore, a business case is not only a tool for decision-makers, but also helps the project team enhance their planning (Brugger, 2005).

Despite the broad spectrum of different projects that could be analyzed, there are guidelines that should be applied to perform a business case analysis, which may be adapted to a specific scenario.

Table 1 summarizes the elements of a business case. This framework will serve as a guideline in developing the business case tool presented in this paper. The first part defines the subject and the purpose, including objectives and motivation, of the specific case analysis.

Definition	Development & Methods	Validation	Results
- Subject - Purpose	- Cost model - Benefit model - Non-financial impact - Financial model - Financial metrics - Scope and main assumptions - Scenario model	- Sensitivity Analysis - Risk analysis	- Conclusion - Recommendation

Table 1. Business Case Structure (adapted from Schmidt, 2002)

The development and methods section highlights the design elements that determine the boundaries of the case. It includes assumptions and models which are used to estimate the benefits and costs. This information is required for the financial model in order to calculate financial metrics such as the net present value (NPV) or the internal rate of return (IRR). This section offers the financial and non-financial business impact as expected in one or more scenarios (Schmidt, 2002). The third section verifies the results of the previous section. This is accomplished through a sensitivity analysis, which examines the influence of the main assumptions on the tangible results. Furthermore, the risk analysis examines the likelihood of each scenario occurring as well as the impact of risk factors on each outcome (Schmidt, 2002). The last section gives an overview of the outcomes of the different scenarios. Based upon the insights of the sensitivity and the risk analysis of the previous section, it is possible to recommend the execution of a specific scenario. Furthermore, the recommendation highlights any unexpected or surprising result that might be important to the retailer (Schmidt, 2002).

RFID Business Case Tools

Several RFID Cost-Benefit Calculators have been developed academia and practice in recent years (for an exemplary subset of well documented and publicly available tools see Table 2 below). To our knowledge, the Auto-ID Calculator (Tellkamp, 2003) was the first approach to calculate the business case for RFID implementations. It is a web-based, mainly cost savings driven tool developed to assess the impact of RFID on a three-echelon supply chain, including a manufacturer, a distributor, and a retailer. It takes different tagging levels into account, but focuses mainly on supply chain applications and processes. However, the benefit calculation can be assessed for each supply chain partner separately. The case developer can choose between ten different expected benefit drivers from RFID, such as "improved stock visibility", a "reduction in inventory", or "reduction of unsalable articles". The Auto-ID Labs Calculator provides a sensitivity analysis and standard financial metrics.

Tool	Year	Scope	Cost-Benefit Focus and Main Features
Auto-ID Calculator	2003	- Three partner supply chain (manufacturer, distributor, retailer) - Supply chain applications and processes	- Cost savings driven - Different tagging levels - Ten different benefit drivers - Sensitivity analysis - Standard financial metrics
EPCglobal Inc. Calculator	2004	- Internal supply chain operations - Manufacturer oriented	- Benefits supply chain problem-centric ("business problems to be eliminated" and "business problems to be enhanced") - Different tagging levels - Direct and indirect impact on manufacturer's profitability
GS1 Calculator	2005	- Supply chain oriented process analysis of benefits	- Costs and benefits are input via a checklist - Different tagging levels - Standard financial metrics
IBM Calculator	2006	- Supply chain focus	- Direct and indirect benefits - Business value model and business process model

Table 2. RFID Business Case Tools (Tellkamp, 2003; Lee, Peleg, Rajwat, Sarma and Subirana, 2004; Vogell, 2005; Leung, Cheng, Lee and Hennessy, 2006)

Among all calculators that we are aware of, the EPCglobal Inc. Calculator (Lee, Peleg, Rajwat, Sarma and Subirana, 2004) has the strongest academic foundation. Its goal is to support manufacturers to systematically analyze their expected benefits of an RFID implementation, while mainly concentrating on internal supply chain operations. It is a spreadsheet-based, customizable tool, which considers an amortization period of 5 years. While costs can be either one-time or recurring, the assumed benefits are supply chain problem-centric and subdivided into "business problems to be eliminated" (such as shrinkage, counterfeiting, or out-of-stock) and "business problems to be enhanced" (such as vendor managed inventory, operational efficiency, or promotions management). Moreover, the benefits depend on the level of tagging (pallet, case, or

item) and the way tags are applied onto goods ("tag at source" or "slap and ship"). These are categorized into: more revenue, more profits, less costs, and a higher service level. For example, time and financial reductions through labor reduction due to absence of manual scanning (people can do something else), would correspond to savings in costs.

Existing RFID cost-benefit calculators were usually developed against the background of supply chain implementations with a focus on logistics operations. In the course of the apparel retail pilot under study, however, the project team found that none of these existing calculators met the specific requirements of the retailer. This was mainly due to the following three reasons:

- **Limited scope**. Existing calculators focus on efficiency gains and optimizations in logistics supply chains;
- **Coarse cost approximations**. For RFID implementations on department store shop floors, cost items are not fine-granular enough, since each fitting room, intelligent shelf, storage room, escalator and elevator gate, and checkout, for example, would represent an individual cost item;
- **Specific benefits**. Existing calculators primarily offer predefined benefit selections, which mainly rely on cost cuttings through time and labor savings. However, in an apparel retail environment, benefits also emerge from new knowledge about customer behavior (obtained by data mining techniques and quantitative data analyses, based on RFID reads), from improvements in store layout, stock management, and improvements in merchandise assortment, for example.

In order to address the aforementioned deficits, we designed and implemented a Cost-Benefit Calculator for RFID implementations in the apparel retail industry. Whereas our work is based on a concrete scenario, the calculator is to be easily employed for similar implementations. This calculator is presented in the following section.

OVERVIEW OF THE APPAREL RETAIL BUSINESS CASE TOOL

Business Case Tool Requirements and Conceptual Approach

The requirements from the department store retailer regarding the RFID Cost-Benefit Calculator were multifold:

- The tool was supposed to give the apparel retailer the possibility to quickly and easily simulate RFID roll-out scenarios, only by varying a minimum number of important "scenario levers" from a user frontend;
- From an investment plan and costs perspective, it was supposed to be fine-granular and flexible enough so that each shop floor in a warehouse could be equipped with RFID technology (with different numbers of floors, and different floor sizes, including fitting rooms, readers at escalators, elevators, checkouts, shelves, and special RFID consumer applications, repeatedly for additional warehouses and shop floors);
- From a benefits perspective, it was supposed to take newly arising insights into in-store processes that lead to improvements in store layout, stock management, and merchandise assortment into account. Moreover, additional benefits like increased sales and increased customer satisfaction from RFID customer applications, which are quite difficult to quantify and monetize, had to be included into the RFID calculator. In addition, due to unforeseen future benefit potentials, it be flexible enough to easily include these drivers;
- The differentiation between savings made by cost cuttings or efficiency gains, and additional sales and revenue on the sales floor was necessary. For example, one Dollar in cost savings generally results in one additional Dollar in return. However, one Dollar in additional sales affects returns by less than a Dollar, because further costs are generated such as the costs for purchase, storage, and personal. This differentiation was essential for determining the return of a specific investment project.
- From an implementation perspective, the business case tool should be able to include the impact of future customer applications into the considerations, both regarding costs and benefits (e.g., recommender systems being deployed only from 2010 on);
- A sensitivity analysis for every element of the business case was regarded as necessary so that the top management of the retail company could evaluate the role of each factor individually in the roll-out scenarios.

For the conceptual approach, we follow the Business Case Structure proposed by Schmidt (2002) as previously described in Table 1.

Subject and Purpose

The subject of the business case is the adoption of RFID technology on the shop floor in retail outlets. Its purpose is to deliver a sound foundation upon which to base decisions on a roll-out of RFID technology to further retail outlets. According to the retailer under study, this decision will mainly depend on three factors: (i) Customer and employee acceptance of the technology, (ii) improvement of business processes, and (iii) profitability of roll-out scenarios.

Cost Model

The resource-based cost model works particularly well for investments in IT (Schmidt, 2002). Every investment object in the business case has its own standardized table of cost items in the tool worksheet. Table 2 provides an exemplary overview of different cost drivers in the apparel retail scenario and the according investment objects.

Main levers of roll-out	**Cost drivers**	**Investment objects**
Headquarters	Central IT systems	RFID-related software components
	Roll-out project management	Employees
	Department for analyzing RFID data	Employees
Distribution centre	Entries and exits	RFID gates and further systems
Store	Receipt of goods	RFID gates
	Storage room	RFID gates and further systems
	Entries and exits for customers	RFID gates
	Decentralized IT systems	RFID-related software components
		Construction work
Floor	Escalator	RFID gates
	Staircase	RFID gates
	Elevator	RFID gates
Sales floor	Shelves	Intelligent Shelves
	Check out	RFID system
	Fitting room	Recommender System
	Sales personnel	Mobile RFID-Devices
	Articles	RFID tag

Table 2. Hierarchy of aggregation applied on retail environment

It is not unusual to see dozens or hundreds of cost items in the cash flow statement, whilst the number of benefit items is usually much smaller. Therefore, it is important that a cost model is taken as a guide to organize and define the cost item categories that belong to the case. In accordance to Izadi and Boyd‘s (2008) total cost of ownership approach, the resource-based approach distinguishes between two dimensions in cost item categorization. On one hand, a set of cost categories according to their IT resources, such as hardware costs (compare Table 2 above), software costs, personnel costs (IT staff), personnel costs (users), network and communication costs, and all other costs. On the other hand, this set of cost categories covers life cycle phases (Schmidt, 2002), such as acquisition and implementation costs, operational costs, and ongoing change and growth costs for future additions, moves and changes to the IT environment. This second dimension of life cycle phases can be simplified by integrating the category of ongoing change and growth costs into the category of operational costs. As a result, the life cycle dimension consists only of one-time investment costs and ongoing operational costs (Schmidt, 2002).

Apart from any investments, other factors have a crucial influence on prices and total costs. In this regard, the business case tool integrates the effect of inflation, productivity of producers through technological progress, and the influence of economies of scale. The first two aspects can be considered as an external trend over time, which cannot be affected by the

retailer. In contrast to this, the retailer has an influence on the impact of economies of scale. This is due to the reason that the dimensions of the roll-out scenario and resulting investments have a direct effect on the potential for economies of scale.

Therefore, each cost item is calculated in the following way:

$$\text{cost item}_{ijk}^{\text{final}} = \text{cost item}_{ij}^{\text{initial 2009}} \times \text{trend factor}_{ijk} \times \text{EoS factor}_{ij}$$

$$\text{trend factor}_{ijk} = \frac{(1+\text{inflation})^{k-2009}}{(1+\text{productivity}_{ij})^{k-2009}}$$

$$\text{EoS factor}_{ij} = f(\text{total purchase}_{ij})$$

investment object: $i \in$ {RFID gate, Recommender Systems, Shelves,...}
cost source: $j \in$ {hardware costs, software costs,...}
year: $k \in$ {2009,..., 2014}

Case developers are asked to determine the cost data ($\text{cost item}_{ij}^{\text{initial 2009}}$) for the first year. However, this data is only an initial basis to calculate the final cost ($\text{cost item}_{ijk}^{\text{final}}$) of each item for the years between 2009 and 2014, because the influence of inflation, productivity gain, and economies of scale must be still taken into consideration. Regarding the influence of inflation and productivity gain ($\text{trend factor}_{ijk}$), the impact is calculated as described in the formula above. Inflation is given in the cockpit worksheet as an average value, which covers all investment objects along the time period. Case developers are asked to estimate the productivity gain of producers for each cost item. For instance, experts might estimate that RFID tag prices will decrease in the future due to annual productivity gains of 20 percent.

Moreover, the case developers are allowed to determine the estimated impact of economies of scale ($EoS\,factor_{ij}$) on every cost item. To conclude, the cost model is able to compute the total costs over time of every investment object according the roll-out scenario, adjusted to inflation, productivity gain, and economies of scale.

Benefit Model and Non-Financial Impact

This section gives a brief introduction to the methodology of measuring the impact of benefits of RFID implementations and how these benefits are implemented into the business case tool. As stated in the first section, the benefits of the apparel retail in-store RFID installation do not only reside in savings through cost cuttings in the supply chain. The benefits mainly arise from results regarding the store layout, the mix of assortment, and the inventory level, for example, gained by RFID data analyses. Moreover, benefits emerge from increased revenue generated by RFID customer applications, such as the Recommender System.

The previous section has shown that there are methods and models that enable to identify costs in a structured way. However, by working on the benefits, case developers will realize that this is associated with many more challenges. For instance, forecasts of increased income are always based on uncertainties and depend upon the reaction of the market. Furthermore, certain impacts of investments might not be evident in the first place: investments could enhance various internal processes, which are difficult to quantify because they have no direct effect on the measurable cash flow (Brugger, 2005). Despite the different sources and impacts of benefits, there is a procedure, which is proven to be a good guideline in working on calculating benefits. It consists of the following three phases (Brugger, 2005):

- **Identification of benefit potentials**: In this most important step, business case developers have to put effort into identifying all possible impacts, in order to achieve a realistic scenario forecast.
- **Quantification of benefit potentials**: The second phase is related to quantification. It is necessary to develop tangible data like figures and indices, because only tangible results ensure comparability among different scenarios.
- **Allocation of financial value**: In the last phase, case developers seek to assign each benefit potential with financial values, which is also referred to as monetization. This financial data is essential for the financial analysis of business cases in order to calculate cash flow statements.

As a result, business cases list benefit potentials, which are integrated into the business case according to the degree of quantification:

- **Direct financial benefits**: These are the potentials that can be straightforwardly integrated into the financial model. They have in common that they are easily identified and are directly measureable in financial terms (Brugger, 2005). Cost saving and increased sales are the source of this kind of benefit potential (Schmidt, 2002)
- **Indirect financial benefits**: The benefits assigned to this category do not have a direct financial impact. Therefore, financial values can be derived based upon quantified data in terms of improvements in time, amount, and resources. For instance, an increase in labor productivity could reduce the spending on salaries (Brugger, 2005).
- **Quantified benefits**: The benefits that are quantified but not monetized can also be considered in a business case. Due to the lack of a financial value, this data cannot be integrated into the financial analysis, but based on percentages or standardized indices, tangible comparisons can be conducted between different scenarios. For instance, the overall customer satisfaction can be expressed as an index.
- **Intangible benefits**: Business case developers could face various intangible benefits. Some issues might not be expressed in tangible form within reason. Increases in good reputation or the conformity of scenarios with corporate strategy are examples of intangible benefits. However, these rather "soft" benefits could be of crucial importance for the business case. Consequently, these aspects are excluded from the financial analysis, but should be highlighted in the conclusion and recommendations of the business case (Schmidt, 2002).

Based on this broad foundation, various analyses can conducted in order to measure the benefits of RFID. However, the question arises how to ensure that alleged benefits, like increases in sales, are originating from the RFID adoption and not from other influences. The pilot project takes place in an open environment and not in a laboratory. Consequently, seasonal effects, weather conditions, or for example fluctuating customer traffic must be taken into account as disturbance factors.

Financial Model

The financial model lays the foundation for the retailer's roll-out requirements. Business case developers have to define each ratio between levers, drivers, and investment objects for the calculation. For instance it could be defined that 1,000 square meters of sales floor (lever) is equipped on average with 8 fitting rooms (driver) and every fitting room will be enhanced with one Recommender System (investment object).

The investment plan for the installation is part of the financial model. The investment plan depends on the lever data, the start of applications, and the ratio of internal or outsourced tagging of articles (whether the retailer tags products on its own or installs a third party). Furthermore, the associated roll-out scenario depends on the assortment and ratios between levers, drivers, and investment objects.

Furthermore, three specific influence factors are taken into account in order to predict the development of prices: inflation, economies of scale, and increases in the productivity of producers. Regarding economies of scale, the user can define a function for every investment object, which depends on the retailer's total demand. Additionally, the user can define the average increase of productivity of producers for every investment object. In this way, the business case considers the decrease in prices due to technological progress.

Financial Metrics

The calculation worksheet summarizes the financial information from the costs worksheet, the benefit worksheet and generates the forecasted cash flow, taking the inflation rate into account. The business case calculator provides cash flow, net present value (NPV), and the internal rate of return (IRR).

Sensitivity and Risk Analysis

The need for taking sensitivities and risks into account in the context of deploying RFID technology is a consequence of various internal and external factors. Examples include:

- **Anti-RFID campaigns** (i.e., data protection activists or civil liberties groups could start initiatives against RFID initiatives, which could influence the perception of consumers to the retailer's disadvantage).
- **Dependencies in the supply chain** due to shortages in RFID-tag supplies or failures in tagging, which might lead to complications in supply chain and warehouse management, as well as to losses in any expected benefits of RFID.
- **Future price developments** on the market for RF transponders, readers, and software components.
- **Switching Costs** arising from the change from existing barcode systems to RFID (Al-Kassab and Rumsch (2008)).

The business case tool incorporates the necessary functionality for conducting sensitivity analyses in its financial model. Each cash flow statement in the last column of the calculation worksheet has its own sensitivity factor. By varying this factor, the case builder can easily determine the effect of each cost or benefit item on the total outcome.

Scope and Main Assumptions

Generally, the scope of the business case defines the range of coverage of the business case along several dimensions (e.g., product category, timeline of the project, its region, and the considered value chain). This information is needed to make a number of structural decisions on the development of the business case, e.g. which costs and benefits have to be included. Additionally, the main assumptions regarding the hierarchy of aggregation and ratios, the development of roll-out, the determination of costs and benefits, etc. are defined.

Scenario Model

The Cost-Benefit Calculator for RFID Implementations in the apparel retail industry is implemented using the Microsoft Excel spreadsheet tool. Excel offers several advantages: first of all, many users are familiar with this software, so they can easily understand, work with and possibly customize the business case tool. The worksheets within the software enable a structured documentation of underlying information. Furthermore, Excel allows for easy processing and exporting of the results. Figure 1 shows the composition of the business case tool. All worksheets are shown as well as any important content. Arrows represent the stream of data from one worksheet to another.

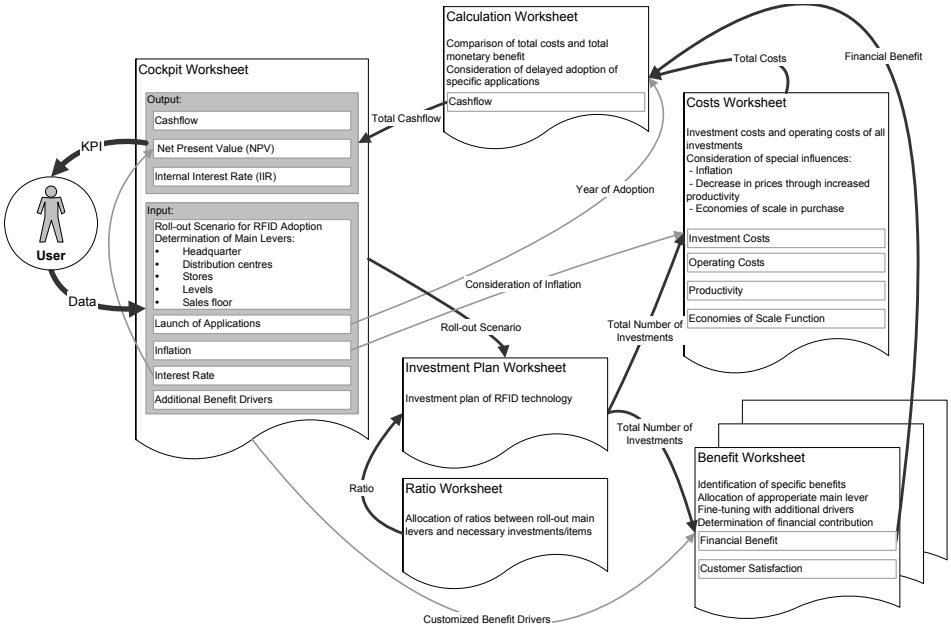


Figure 1. Overview of the Business Case Tool

Table 3 illustrates the matching between the worksheets and the described Business Case Structure (c.f. Table 1):

Cost Worksheet	**Cost Model**
Benefit Worksheet	Benefit Model and Non-financial Impact
Investment Plan Worksheet	Financial Model
Calculation Worksheet	Sensitivity Analysis, Financial Metrics
Cockpit Worksheet	Scenario Model

Table 3. Matching worksheets to Business Case Structure

SUMMARY AND OUTLOOK

In this paper we presented a Cost-Benefit Calculator for RFID implementations in department stores. Our approach considers the cost savings through process improvements (e.g., labor costs), the specific benefits of the apparel retail industry, such as additional revenue from RFID consumer applications (e.g., recommender systems, installed in fitting rooms), improved shop floor layout, optimized product assortment, inventory levels, management of sales personnel, merchandise performance, category management, reordering, purchasing, shelf replenishment, and inventory level controls. The current version of the tool was implemented for an ongoing real-world RFID apparel pilot. First findings imply that most benefit drivers arise on the managerial level and that time, cost and labor savings on the operational level come second.

The cost-benefit calculator was conceptually validated by the retailer under study. On the one hand, it allows for a fine-granular input of cost items and a fine-granular cost-calculation on the sales floor level for the "in-store supply chain", thus allowing for an easy and fast simulation of roll-out scenarios by only changing a small number of levers in the tool's cockpit. On the other hand, it enables the retailer to flexibly include the above mentioned benefit drivers and provides a direct output of the cash flow and NPV numbers for each scenario. Further research will be necessary to evaluate the applicability of the tool in different project settings. The real benefits of our calculator as well as the validity of the underlying model can only be evaluated in a long-term study.

We see a number of opportunities for enhancements, e.g., through the use of simulations, which complement the cost-benefits calculator in order to adequately evaluate and include retail process transformations. A second are for future research should be the quantification of benefits through improved management information arising from the results of RFID data analyses, which require alternative evaluation procedures.

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