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TECHNOLOGICAL INNOVATIONS AS DRIVERS OF RETAIL 4.0 – HOW RFID COULD IMPROVE RETURNABLE BOTTLE LOGISTICS IN THE GERMAN BEVERAGE INDUSTRY

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Abstract. This research paper discusses how RFID technology could improve current deposit bottle logistic processes in food retailing and which obstacles impede successful implementations. Research Methodology include desk research: Library, EBSCOhost, wiso.net, Google Scholar, Scientific Journals, Statista, SpringerLink. Implementation of RFID is potentially beneficial, but same obstacles remain outlook. To validate the conclusion further studying and practical proof of concept are necessary. Contributions: supply chain management, return logistics, food retail, beverage industry.

Keywords: *deposit bottle, food retailing, return logistics, reusable packaging, RFID.*

Rezumat. Această lucrare analizează modul în care tehnologia RFID ar putea îmbunătăți procesele logistice actuale ale sticlelor de depozit în comerțul cu amănuntul a alimentelor și obstacolele care împiedică implementările de succes. Metodologia cercetării include cercetare de birou: Library, EBSCOhost, wiso.net, Google Scholar, Scientific Journals, Statista, SpringerLink. Implementarea RFID este potențial benefică, dar rămân anumite obstacole. Pentru a valida concluzia, sunt necesare studii suplimentare și dovada practică a conceptului. Contribuții: managementul lanțului de aprovizionare, logistica returului, retail alimentar, industria băuturilor.

Cuvinte cheie: *sticla de depozit, vânzare cu amănuntul de alimente, logistică retur, ambalaje reutilizabile, RFID.*

Introduction

Logistics are currently undergoing a process of change, foremost due to technical innovations. Radio Frequency Identification (RFID), the main driver of the change, is a very promising technology that can be implemented to solve the challenges arising in the logistics sector. RFID systems have been used for several years and can now be considered a mature technology. Nowadays, they are being implemented in numerous different areas. The strong growing prevalence of RFID in Europe is illustrated in the figure below.

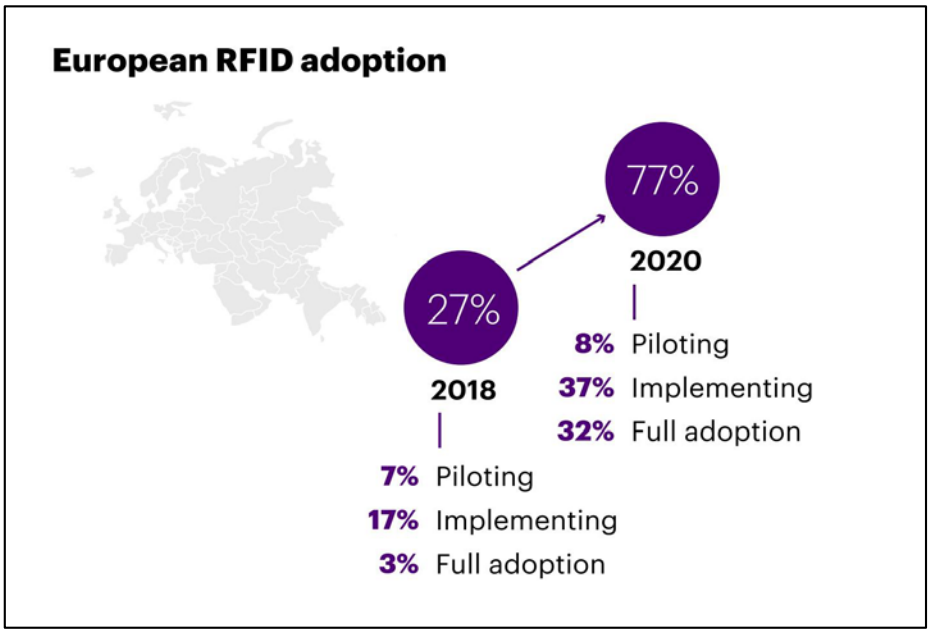

Figure 15. RFID adoption on the rise in Europe [1].

By nature, many logistics systems are very complex. A particularly sophisticated logistic system constitutes the reusable beverage container system in Germany. Therefore, not only good delivery logistics must be provided, but also complex return logistics [2]. Because of a growing diversification of the beverage containers' shapes and sizes, the logistical effort, e.g., in sorting, is strongly increasing. The sorting of the reusable containers is often carried out by hand and is thus labor and cost-intensive. Despite its complexity, the reusable beverage system is highly appreciated by politicians because it aligns with the environmental policy goals to decrease the use of packaging, allows to save resources, and has a positive impact on the environment [3]. Reusable systems are becoming more and more common in Germany. Consequently, the effort the retail sector must make is increasing noticeably. This is also the case for other stations of the comprehensive logistics system. Because of this need for improvement, the question arises to what extent RFID technology could help to optimize these sophisticated logistics systems and thus reduce the costs in local trade [4]. The focus lies on efficiency, that is to say on the optimization of the logistics system [5]. Relevant reference factors for this are time, space requirements, personnel requirements, and costs. In the following research paper, findings on this question are to be brought together, compared and weighed up to conclude on RFID systems in reusable bottle logistics.

1. Literature review and hypothesis development

RFID is a widely applied technology in logistics; therefore, many different publications can be found on issues surrounding the use of RFID systems in logistics processes, also with a focus on the use and implementation in the retail industry. A deeper examination of this topic reveals that most case studies and research papers only deal with the consideration of delivery logistics [6]. However, case studies that also examine the effects on return logistics are much rarer. In addition, the individual studies on RFID in return logistics often deal with cases of pool systems up to the retailer level, such as the Euro pallet system [7]. In countries like Germany, however, there are also pool systems that go down to the consumer level. The most prominent example of this is the returnable deposit system for beverage containers such as beer bottles or water bottles. These bottles, made of glass or PET, run in an even

more complex cycle than the before-mentioned Euro pallets. The reason why this system is even more complex is due to a large number of different types of containers, which are difficult to take back and to sort. Furthermore, there are often returned by customers in a shop that is different from the shop of original purchase [8].
Since such a logistics system has not yet been discussed in a research paper that I know of, this paper takes this as an opportunity to deal with the question of how useful it would be to implement RFID technology at the item level in a returnable bottle system. To answer this question, the existing literature on RFID in retail logistics is analysed. Potential opportunities and risks of such an implementation are highlighted and a conclusion is derived from this.
Before we take a closer view into the effects of RFID implementation in supply chains, the technology should be explained to ensure a solid ground of understanding.

1.1 Explanation of RFID Technology

A system using RFID which is the abbreviation for Radio Frequency Identification consists of two major components: a tag and a reader [9]. The electronic tag is affixed or embedded in an object and contains historical, transactional, or identifying data. This data can be wirelessly downloaded to a computer if an RFID reader is near the tag. After this point where the gathered information is loaded onto a computer, the data can travel anywhere on the internet [10].

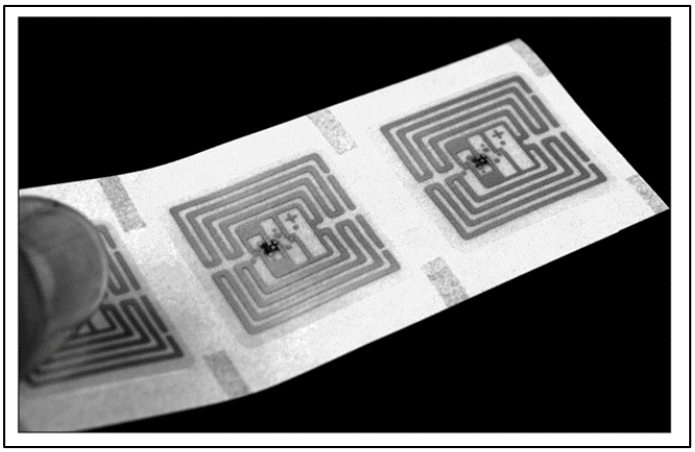

Figure 16. Picture of RFID tags [11].

There are two different types of tags. Active RFID tags are battery-powered. Passive tags have no power source. Therefore, they require electromagnetic power transmitted by the reading device to enable information exchange [12]. Each type of RFID tag has its advantages and disadvantages. The active tag provides a higher reading accuracy but has a costly price point due to increased complexity. Besides active tags are less robust and more difficult to be integrated with packages [12]. On the contrary passive tags have a simple structure, are more robust, last longer in storage, radiate less energy, and are cheaper [12].
Nowadays RFID tags can be complemented with RFID sensors. If these RFID using circuits are combined in a label this enables further functionality such as food quality monitoring. The following Figure 3 gives an overview of the different purposes and functionalities.
As you can see an RFID-based sensor system can combine identification with sensing purposes that can measure changes in physical parameters [12]. The enabling technology behind these additional functions is smart materials, which are responding to the physical change of environmental factors.

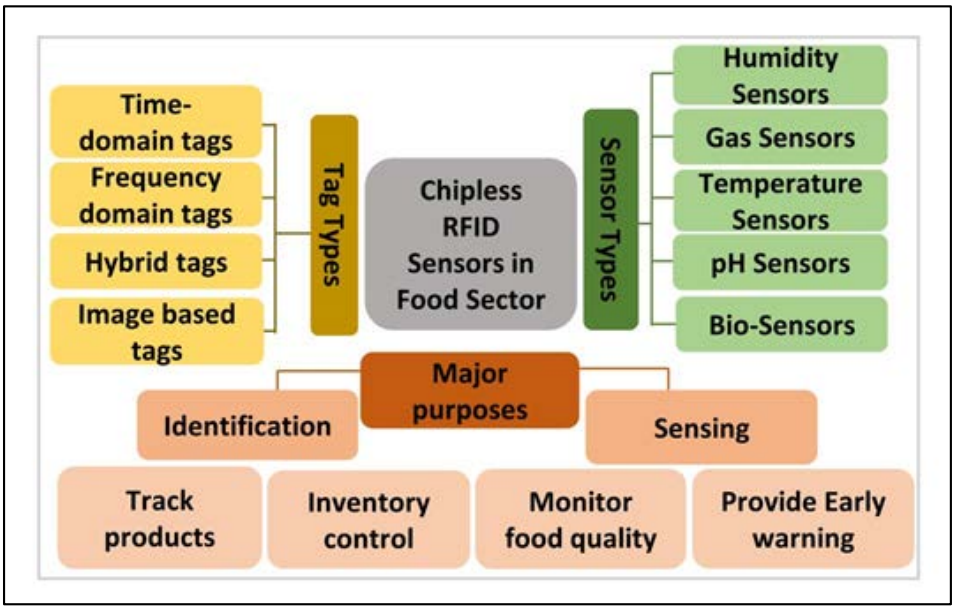

Figure 17. The framework of chipless RFID sensors in food packaging [12].

Smart materials are the fundamental elements of chipless RFID sensors. They react to changes in environmental factors such as humidity, temperature, the concentration of gases, pH, and light [12]. On the technical side, those functions are realized by changes in electrical properties [12]. While sensing purposes can be used to surveillance of freshness the identification part can be used to deliver sales, location, and demand structure information. [13]. These characteristics make combined RFID sensors with tracking and quality monitoring especially interesting for the food retailing industry.
Now that we have defined and explained RFID technology, I am going to review the different works of literature in this subject area.

1.2 Literature Review

Some of the earlier literature about RFID implementation focused on practical goals, such as reducing labor requirements and spoilage through efficient inventory management [14]. Despite uncertainties about costs and dispersion, the major retailers were very hopeful and expected to save billions of dollars if goods were equipped with RFID across the board, as this would make it easier to prevent theft [15]. Another issue that arose at the beginning of this millennium was the definition of common guidelines and standards. With the choice of EPCglobal in 2003, however, standardization was established [16].
A key challenge that acts as an inhibiting factor to widespread deployment is the price per RFID tag. Although the price of cheap, mass-produced RFID tags has fallen from €0.50 in 2007 to between €0.10 and €0.15 in 2010, RFID labels are still too expensive for item-level tagging despite the sharp drop in price over these three years [11]. This observation also serves as an explanation for the fact that retailers like Metro, which were initially very optimistic, do not have item-level tagging yet, as shown in the figure below.
Nevertheless, the prices per tag are currently still a degree too high, the RFID technology has come to stay, and the experience shows that the most innovative and adaptive retailers are discovering many new use cases besides typical inventory tracking [1]. New use cases could outline an overall positive effect on retailer's profitability.

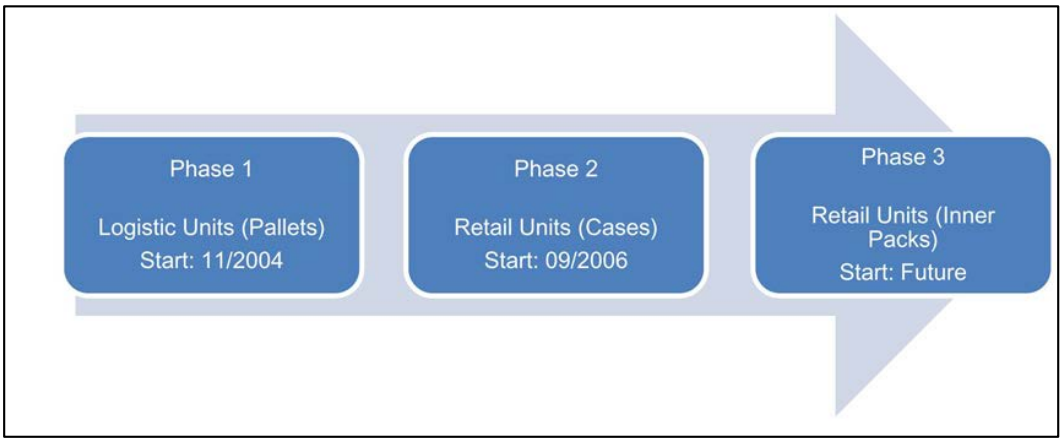

Figure 18. RFID roll-out phases at Metro [13].

In the case of multiple used returnable deposit bottles, there is a different view on the RFID tag price because the label costs can be allocated to the number of circulations. This means that slightly higher label costs are less of a problem.

1.3 Hypothesis development

If we take into consideration that the sorting process after the return of the bottles at the deposit vending machine is still very labor-intensive and requires manual work RFID-based automation appears as a suitable solution to optimize the handling with returnable bottles. Additionally, the results of other RFID implementation projects have proven a positive effect on efficiency and profitability several times.

This induces me to formulate the following hypothesis: An area-wide implementation of RFID for returnable beverage bottles would lead to a significant increase in efficiency and profitability of this pool system.

2. Research methodology

To fulfil the standards of proper research, it is essential to carry it out through appropriate data collection in terms of quality and quantity. The data used for this research paper consists of a collection of theoretical data. Theoretical data includes literature, journal articles, and internet documents.

The used literature and further resources were gathered through using different scientific search engines, for instance, the DHBW library, EBSCO, Google Scholar, Springer Link, and wiso.net. Subsequently, the main arguments were outlined and opposed. Advantages and disadvantages were weighed. In the conclusion, the personal view was brought in to draw an outlook.

There are two main ways to execute a research assignment, deductive or inductive. This research is deductive, which follows the approach of seeking truth by looking from different directions. Therefore, the deductive way of researching tests primarily existing theory [13].

3. Results and discussions

To be able to make a balanced statement about whether implementation of RFID would be beneficial, the following comparison of arguments for and against it is presented.

3.1 Challenges and Obstacles with RFID

- Besides the smart tags themselves, the other main cost components are the stationary readers and the corresponding IT infrastructure. The tag cost is variable, while the

installation of the readers and the adaptation of the IT infrastructure are primarily fixed costs [17].

- The collaboration leads to a continuously increasing complexity in handling information along supply chains due to a larger extent of data necessity and flow [13].
- Studies have identified cost-sharing as an obstacle; it is not symmetrically distributed. Looking at the supply chain as a whole, the dilemma becomes clear: item-level labeling seems to offer the greatest potential for the retailer but is the most expensive solution for the manufacturer who is best able to apply the labels [17].
- Cyber security risk: Attackers can read, misuse, falsify, destroy, or damage by mechanical means, remove or render unusable by shielding data exchanged between RFID tags and readers. Possible consequences would be a misuse of information, price manipulation, and product piracy [18].
- Technical problems, disturbances in the labeling of cans and other metal-containing products have not yet been solved [16].
- Rather than profitability, the central problem is sometimes that the critical mass of participating suppliers is not reached, as it happened to Rewe's RFID project "PERL" that was discontinued in 2007 for this reason [19].
- If there is a mix with items that are not RFID-tagged they will drag the efficiency of the store down by an amount that exceeds its 'share', so it should be considered to change all items from barcode to RFID at the same time [20].
- Further the following technical characteristics are implying the limitation of the RFID technology [12].
    - Reading accuracy is dependent on multiple factors and sometimes fail
    - Reading range is limited to very few meters
    - Conformability (Performance on flexible packaging) hasn't been widely tested
    - Fabrication/Production: Cost reduction and high-volume output is still challenging
    - Data capacity is technically limited
    - optimal tag placement on the item unclear [21]
- Especially with returnable bottles made of glass or PET the effect of RFID labels on their recyclability is likely to be negative [12]. It can be assumed that RFID labels have to be detached before recycling.
- Returnable bottles are thoroughly cleaned after a return. It is unclear whether adhesive RFID labels survive a cleaning cycle undamaged. If not, this would have a significant impact on the financial calculation of cost allocation in circulation.
- In implementing RFID there are five major struggles and roadblocks:
    (a) lack of technical expertise, [22]
    (b) the complexity of the technology, and [22]
    (c) uncertainty of the technology [22].
    (d) identifying the right suppliers and partners [1]
    (e) quantifying the value of RFID [1]

3.2 Potential and Benefits with RFID

- Retailers are seeing the benefits of RFID in generating massive amounts of data that fuels insights, facilitate greater accuracy of inventory, and it is a key enabler of omnichannel capabilities [1].

- Applying RFID technology additionally enables monitoring food quality inside the individual packages which helps retailers and consumers with the handling of fresh food [12].
- From the customer's perspective shopping becomes a more convenient experience, thanks to the wide range of RFID applications. It is conceivable that customers will be able to call up additional product information or even cooking recipes via the RFID chip [9].
- Advantages for the customer: In a matter of seconds, the scanner at the checkout reads all the codes without having to unload the goods from the shopping cart and place them on a belt [23].
- For retailers: many inventory-relevant work steps can be enormously simplified and accelerated, thus liberating personnel capacities. At goods receipt, it is no longer necessary to scan individual pallets or products; instead, by passing through an RFID-powered receipt gate, a complete delivery can be booked into the inventory - virtually without any time delay [24].
- Case studies show that by implementing RFID systems the quota of container losses is reduced [25].
- RFID-enabled processes are more efficient due to the elimination of errors caused by manual verification [10].
- RFID in logistics systems reduces shrinkage and improves cash flow by quicker billing because quantities can be easily compared and reconciled instantaneously [10].
- The very notable potential to reduce the out-of-stock rate of suppliers' products which implies a large savings potential, as the average stock-out rate vary between 7-10 percent [14].
- A study using the regression analysis with Cobb–Douglas production function shows that RFID retailers have higher labor to gross income elasticity than their non-RFID counterparts, indicating that RFID retailers have higher labor productivity [26].
- Consequently, because of the higher labor productivity a lower number of workers is required, which is viewed positively due to the increasing shortage of skilled workers [27].
- New research by Accenture states retailers that have fully adopted RFID are reporting more than 10% return on investment [1]
- Further they found that retailers that have engaged with suppliers on source tagging are seeing a higher return on investment (16% higher) than those who have not [1].
- With reusable and recyclable RFID transport containers a great cost-efficiency can be achieved because the same transponder can be utilized several times [14].

The following Figure shows the development of the potential cost for RFID labels if they can be reused on circulating deposit bottles.

Figure 5 implicates that the price of one RFID label becomes less relevant in a reusable container system. As a result, the mentioned benefits overweigh the disadvantages on the pricey side. Therefore, an implementation of RFID seems to be more attractive than first assumed. The prerequisite is that the RFID labels are not damaged when the containers are cleaned. This is unclear for adhesive labels. Molded-in RFID tags, on the other hand, do not pose any problems when it comes to cleaning. Besides variable costs, there are additional launch costs for computer software and RFID reader hardware, which are about 1000 € per reading device [12].

RFID type/circulations	1	15	20	25	35	50
adhesive label	0,10 €	0,007 €	0,005 €	0,004 €	0,0029 €	0,002 €
in-mould label	0,15 €	0,01 €	0,0075 €	0,006 €	0,0043 €	0,003

Figure 19. *Cost development of RFID labels used on circulation reusable bottles. (own graphic)*

Because of these pertinent set-up costs, the recommendation is to run a proof of concept first. If the first initiative shows successful outcomes a wider adoption process should be started.

Conclusion

After taking a closer look at the RFID-based supply chain process, various challenges and opportunities were illuminated. The reviewed literature stated consistently that the implementation of RFID in supply chains increases the efficiency of related logistic processes. [28] Despite increased efficiency, a positive effect on the profitability of the companies using RFID was unclear for quite some time.[29] The latest data shows a positive double-digit return on investment when RFID has been implemented. [1]

In the case of the specific system of reusable deposit bottles there lies an interesting opportunity for further optimization in retail logistics. Even though there are some obstacles and unanswered questions, the considered case is attractive in the sense that the advantages on the item level take effect in interaction with slighter cost disadvantages, due to reusability. Furthermore, in the current operating process, there is a substantial amount of labor tied to the manual sorting of bottles. Due to automatization, this labor could be liberated, and costs reduced. As a conclusion, I recommend setting up an empirical proof of concept to discover if the theoretical approach is also practically correct.

Limitation

This research paper only provides a narrow scope of how RFID works and where chances and opportunities lie and propose an idea of an interesting case for further analysis. Because reverse logistics are complicated and I do not have sufficient knowledge in this area of logistics, I can't predict barriers that arise in the practical implementation. Therefore, I propose to use this provided idea to turn it into a limited proof of concept to validate if it's also empirical sensible to implement RFID in reusable bottles

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