

RFID as An Element of Economy 4.0 Used to Create Sustainable Supply Chains

S Konecka and A Maryniak

Department of Logistics and Transport, Poznań University of Economics and Business,
Al. Niepodległości 10, 61-875 Poznań, Poland

Sylwia.Konecka@ue.poznan.pl

Abstract. Currently, a necessity to create sustainable supply chains is stressed more and more often. The achievements of intelligent and innovative technologies significantly facilitate this process. Practically each of technological creations of industry 4.0 may, to a greater or lesser extent, contribute to the increase of environmental, economical and social effectiveness of supply chains. In this paper, the focus is placed on the RFID technology which has a broad scope of application in the logistics of business and non-business entities. The aim of the paper is specifying the role of RFID in the creation of sustainable supply chains as well as presenting the model connected with this issue which may be tested in various market conditions. The suggestions of empirical studies are placed within the background of other technologies of the fourth industrial revolution.

1. Introduction

RFID (Radio-Frequency Identification) is considered a basic technology among other industry 4.0 technologies. For instance, Liao et al. [1] differentiate the following technologies alongside radio identification: Advanced Robotics, Cloud Computing, Cognitive Computing, Cybersecurity, Internet of Things, Big Data/Analytics, 3D Printing, Mobile Technologies, Machine-to-Machine, Mobile Technologies. Türkes et al. [2] enumerate the following industry 4.0 technologies alongside RFID: Big Data & Analytics, Cyber-Security, Additive Manufacturing, Augmented Reality, Autonomous Robots, Simulation, Horizontal & Vertical System Integration, Internet of Things (IoT), Cloud Computing, Artificial Intelligence, Real-time locating system (RTLS) technologies, Mobile Technologies. Despite the fact that each of the classifications which we may find in subject literature is a bit different, most of them mention RFID. It is a prospective technology whose assets should be discussed within various contexts. More and more studies with regard to the radio technology are conducted every year, but still one may observe that the promising research spheres include a combination of the issues connected with RFID, supply chains, sustainable development as well as other innovative and intelligent industry 4.0 technologies. Therefore, it is valid to create a conceptual model used to evaluate the process and results of implementation of RFID technologies through the prism of creation of sustainable supply chains and the benefits resulting from the simultaneous use of other modern technologies.

2. The use of RFID on the context of creation of sustainable supply chains

RFID systems have a broad scope of application. For instance, they may be used at airports (in the process of luggage identification), in libraries (in the process of managing book returns), in hospitals (for marking surgical equipment), in transactions for the use of highways and in veterinary service (for



recording basic data, such as the date of birth of an animal or the date of vaccination). This system may also be applied to protect valuable objects and it may be used in military service. Due to a necessity to track particular parts of goods in emergency situations, RFID is indispensable in food [3], pharmaceutical [4, 5], automotive industries [6] and retail [7]. Green et al. [8] specifically focus on the impact of RFID technology in combination with green supply chain management (GSCM) practices on environmental sustainability.

The most commonly discussed RFID assets refer to the acceleration of reaction to the changing demand, the decrease in the amount of manual works, support in complementing goods on time and their tracking [9]. Still, there is a need for a wider diffusion of knowledge and empirical studies concerning RFID assets - in the context of the sustainable supply chain. It is important since from the point of view of the costs of system implementation, its implementation may quickly become unprofitable. Taking into account the economic benefits in the longer run as well as social and environmental benefits, it may turn out that the system implementation is valid. The creation of the sustainable supply chain may indirectly lead to the improvement of image, the increase in market share as well as to higher turnovers and revenues.

That is why there is a need to create theoretical models to conduct empirical studies connected with the use of RFID in the creation of the socially-responsible chains.

RFID may be applied in the assessment of the amount of reusable goods and components. In the opinion of Lee and Chan [10], according to the RFID tag, the human computer interface can display the product information such as model numbers and series numbers of the products, manufactured dates, names of retailers and distributors. Passing through RFID middleware, duplicated reading can be cleaned and filtered so as to acquire the useful input for GA (Genetic Algorithm). GA is a meta-heuristics approach which is utilized to determine the best location of each collection point by optimizing the quantity of returned goods, thereby taking an advantage of economics of scales. For instance, added introduction of stress sensors to components provides the capability of knowing the stress properties of steel over its working life, another considerable advantage in assessing an element for its reuse [11]. The readers may also be successfully used in the management of returnable packages. [12].

One of the examples of the RFID application in the context of sustainable activities is also construction industry. The readers may be used at every stage of construction, from design, through construction activities up to ending the construction process. Their detailed application at each stage is for instance discussed by Cheng and Chang [13]. Prefabricated buildings are the main characteristics of the sustainable development of construction industry, the integration of the supply chain of the project life cycle, emphasizes the decisive automation and intelligent technology [14]. The main advantage of the readers is a decrease in material waste. Their greatest asset is seen in the processes connected with the liquidation of premises and in the processes of changes of their use.

Deployment of radio frequency identification (RFID) technologies suggest potential for information exchange between real buildings and virtual models to facilitate operational aspects of whole life change and ultimately the safe and useful disposal of buildings [15].

Yet another beneficial RFID application in sustainable activities is a possibility of reducing the CO₂ emission. The possibilities of calculating environmental and economical effects are presented in subject literature [16].

Specific application of RFID in sustainable activities can be seen in the seafood supply chains. This system facilitates solving problems connected with illegal, unregulated and unreported fishing. These problems may occur in every aspect of water food supply chains, including breeding, processing, distribution and sales. The creation of retrospective platforms, enabling tracking products, may facilitate the creation of the water food supply chains [17].

Ullah and Sarkar [18] proposed system uses Radio Frequency Identification (RFID) devices to improve the end of life/end of use (EOL/EOU) management of cell phones.

Some authors emphasize the importance of RFID technology not only for decrease inventory but also to strengthen coordination in the supply chain [19].

The use of RFID for flows of fresh food products may be particularly important.

Yan et al. [20] and Bottani et al. [3] discuss the sustainable development of a fresh agricultural product (FAP) supply chain, which consists of one manufacturer and one retailer, from the perspective of supply chain coordination. They have established the profit models of the three FAP supply chains before and after investment in the radio-frequency identification (RFID) technique. The models were compared and the critical values of the cost of the RFID tags were calculated. Finally, they obtained the sustainable development of the FAP supply chain.

The forest industry also has RFID applications. Mtibaa, Chaabane [21] and Kaakkurivaara, [22] proposed solution is validated in the Canadian forestry context and demonstrates the additional value of creating a sustainable wood value chain.

Duraccio, Elia and Forcina, [23] discussed using the RFID technology in the supply chains of pallets. Follow these instructions as carefully as possible so all articles within a conference have the same style to the title page. This paragraph follows a section title so it should not be indented.

3. The conceptual model

The conceptual model was based on a literature review from the Scopus database, conducted in July 2019. Keywords used to search for links between sustainable supply chains and RFID were: "Sustainable Supply Chain" or "Social Responsibility in Supply Chain" or "Sustainability and Supply Chain" or "Supply Chain Responsibility" and „RFID". The search result yielded 1769 documents, dating from 2000 to 2020. The selection process revealed that there were 74 publications on RFID. Among the 74 articles retrieved popping up keywords such as: technology, Internet of Things, Information Management, Industrial Management, RFID Technology, Supply Chain Management, RFID, Radio Frequency Identification (RFID), Supply Chains.

Analyzing the publication dates of individual articles, it should be stated that there were no articles covering these areas earlier than in 2004, although RFID technology itself has been known since the 1950s. The subject area of the articles was most often associated with Engineering, Computer Science, Business, Management and Accounting, to a lesser extent they concerned Decision Science, Environmental Science, Agricultural and Biological Science, Energy and Social Science, and also in a few cases Physics and Astronomy and Chemistry.

In the conceptual model (figure 1) - used to test the sustainable effects connected with the implementation of RFID technologies in supply chains - the business supply chains are understood as the ones created primarily due to a will to achieve profit. These include, for instance, the supply chains in the automotive, household appliances and in the food industry. The non-business supply chains are understood as the ones whose main aim is not connected with profitability. These chains include supply chains used in urban logistics, healthcare, in rescue services, etc.

Sustainable supply chains are understood as the ones in which it is important to achieve environmental, social and economical balance and whose beneficiaries are both the stakeholders constituting the supply chain (e.g. suppliers, logistics operators), stakeholders from beyond the supply chain (e.g. local community) as well as the so-called silent stakeholders (environmental well-being).

From a theoretical point of view, the supply chains dedicated for non-business effects shall above all achieve social results. Still, the use of RFID technologies may also contribute to achieving economical and environmental results.

Business supply chains shall achieve positive economical results and the ones aiming at promoting socially-responsible activities shall also achieve positive social and environmental effects.

The first group of facilitators concerns the technologies such as: Blockchain, Cloud Computing, Internet of Things. The second group includes the technologies such as: Virtual and augmented reality, Globalization (GPS/IP), 3D Printing.

The adopted research scheme completes the existing propositions of model approaches with regard to RFID technologies and within the scope of the sustainable supply chains [24]. The overviews of research frames for SSC [25] disclose insufficient exposure of the role of technology in the creation of

sustainable supply chains. The overview works connected with RFID show that the issue of technological influence on sustainable activities is a weakly explored research field.

What is more, on the basis of subject literature review, one may conclude that:

- RFID technology is described mainly at the level of individual links with a big focus on its advantages and disadvantages,
- the use of RFID in sustainable activities of supply chains refers mostly to the green supply chain,
- the empirical studies which indicate the role of RFID in relation to other 4.0 technologies are lacking,
- the studies on RFID in a wider context, not only operational one but also strategic and tactical, are lacking. Only Kaakurivaara [22] compares RFID and barcode and Sun et al. [26] shows the advantage of NFC over RFID.

Therefore, the proposed research model includes all aspects which have been poorly described up to this point.

A starting point for the creation of the research model is constituted by six basic dimensions which are important while creating industry 4.0, proposed by a consulting company KPMG, i.e.: strategy & business model, services & networks (in this study treated as the supply chain), systems & processes, employees & competences, finance & risk management, technology. In order to extend the issues connected with technological aspects, their division into various roles, proposed by a consulting company Deloitte, was used. It was presented in the so-called "PDP loop" which includes [27]:

- physical to digital: capture information from the physical world and create a digital record from physical data,
- digital to digital: share information and uncover meaningful insights using advanced analytics, scenario analysis, and artificial intelligence,
- digital to physical: apply algorithms to translate digital-world decisions to effective data, to spur action and change in the physical world.

These are technologies such as: GPS, blockchain, virtual and augmented reality.

Their wide spectrum can be seen in numerous papers [28, 29, 30, 2].

Since the sustainable supply chain is a main point of reference of the conducted considerations, the results side includes three basic effects connected with it, namely: environmental, social and economical effects.

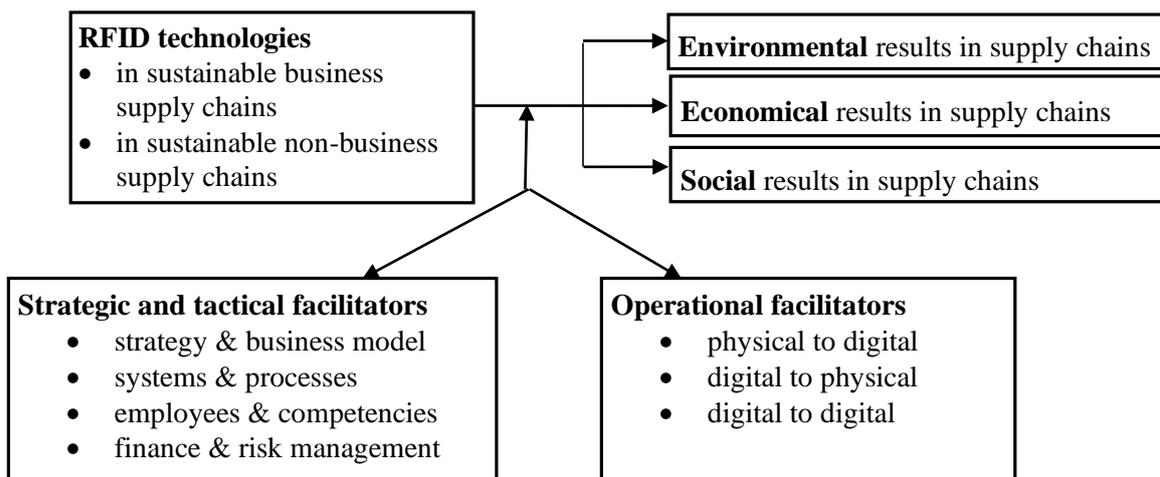


Figure 1. Research model – RFID implementation in sustainable supply chains

In the context of RFID technologies, it is valid to pose a question concerning the effects achieved as a result of the use of radio technology in particular types of supply chains as well as to ask whether related and ancillary technologies multiply the achieved effects. In the light of the above, the following two basic hypotheses were formed:

- H1. The creation of sustainable supply chains with the use of the RFID technology positively influence the environmental, economical and social results.
- H2. The creation of sustainable supply chains bring better environmental, economical and social effects in co-existence with other technologies of industry 4.0.
- H3. The level of environmental, economical and social results depends on the type of the leading strategy, business model, the advancement of the systemic and process approach in enterprises, the availability of competent staff with regard to economy 4.0, financial capability of enterprises and the level of risk of conducted activities.

The mentioned hypotheses, according to the conceptual model, may be divided into partial hypotheses concerning various types of supply chains, various dimensions of achieved results and various types of applied technologies of industry 4.0.

The presented research concept may be also extended by a dynamic approach in which the chronology of implementation of particular tools shall be analyzed in order to determine in which time and technological configuration the RFID technology shall be implemented to achieve the best socially-responsible effects.

4. Conclusions

As stressed in the subject literature based on overview bibliometric studies, there are not many works devoted to the issue of the combination of industry 4.0 and sustainable supply chains [31]. The extended studies of particular technologies, including the role of radio identification in the context of sustainable activities [32, 33, 16] are also missing. This paper focuses on one selected technology, but the presented research scheme may be also dedicated to other innovative and intelligent technologies which support the creation of sustainable supply chains.

The potential of possibilities of RFID application is increasing together with the parallel application of other technologies of industry 4.0 [34, 35]. Still, the empirical studies in this regard are at a very early stage of development. Therefore, the diagnosed research gap and the proposed research directions may be a valuable inspiration for the world of science and business to reflect upon the ways and chronology of RFID implementation in order to create sustainable supply chains.

Acknowledgments

Publication and research financed from funds for Young Scientists and PhD Students under the project "Innovation and modern information technologies in supply chain management" 511132546 and "Networks in the economy" 51112293 Poznań University of Economics and Business.

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