RESEARCH ON APPLYING RADIO FREQUENCY IDENTIFICATION TECHNOLOGY AT LITHUANIAN COMPANIES

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Abstract. In the present article, supply chain management is analysed as a key factor in business competitiveness. Since information and its management are seen as important elements of competitive advantage, various information systems support effective supply chain management and decision making. Radio frequency identification (RFID), which is known as a wireless identification technology that allows tracking the movement of the material flow within the supply chain, is one of the means. In Lithuania, RFID is a relatively new technology; therefore, the article aims at determining the level of applying RFID technologies at Lithuanian companies and the factors affecting it. In the article, the following methods of scientific research were employed: comparative analysis, synthesis and questionnaire method.

Keywords: business, technology, effectiveness, radio frequency, supply chain.

Jel classification: M15, M16, O14, O31

1. Introduction

Supply chain management is becoming one of the key factors in business competitiveness as it involves the optimization of the effectiveness of movement and management costs of the material flow. In nowadays' business, information and its management are seen as important elements of competitive advantage; therefore, various information systems used in the optimization of business processes, such as CRM, ERP, BI and etc., support effective supply chain management and decision making (Davidavičienė, Raudeliūnienė 2010). One of the means becoming more frequently used is a radio frequency identification (RFID) which is known as a wireless identification technology that allows tracking the movement of the material flow and improves its visibility throughout the entire supply chain. The employment of this technology preconditions effective use of both human and material resources, rational business planning and organization and proper decision making. One of the advantages of RFID technology is its broad applicability in both commercial and public sectors, where accurate data collection and real-time information tracking are required.

RFID is a relatively new and rarely used technology in Lithuania. Considering these issues, the article discusses the causes of the low level of applying radio frequency identification technologies at Lithuanian companies.

The aim of the present article is to determine the level of applying RFID technologies at Lithuanian companies and the factors affecting it.

In the article, the following methods of scientific research are employed: comparative analysis, synthesis and questionnaire method.

2. RFID technologies

In nowadays' rapidly changing global environment, in order to both stay competitive in business and win new markets, it is highly important to adapt to the changing conditions of business environment quickly and improve business effectiveness continually (Li *et al.* 2010; Dobson, Todd 2006; Park *et al.* 2010; Curtin *et al.* 2007; Wyld 2006).

One of the most important strategic decisions for achieving and maintaining competitive advantage is installation of technological innovations that meet business requirements (Davidavičienė, Meidutė 2011; Park *et al.* 2010; Davidavičienė 2008; Hansen, Gillert 2008; Bottani, Rizzi 2008; Angeles 2005; Hardgrave, Miller 2006). As a result, radio frequency identification technologies, bringing new opportunities for business management, have received much attention from both businessmen and scientists. RFID creates new perspectives in such business areas as manufacturing, transportation, distribution, warehousing, commerce, marketing and customer service.

The distinctive feature of RFID is its ability to integrate and coordinate all supply chain activities both inside and outside the company (Park *et al.* 2010). As Ju *et al.* (2008) have stated, RFID is easily adaptable to supply chain management; however, other authors (Barjis, Wamba 2010; Collins *et al.* 2010; Smart *et al.* 2010; Shien-Chiang 2008; Tajima 2007; Bean 2006; Spekman, Sweeny 2006) refer to its wider applicability in such areas as health care, environmental protection, security and safety systems, data collection, librarianship and management of many other processes.

RFID belongs to a type of automatic identification technologies used to identify physical items by employing frequencies of radio waves (Kwok 2009; Karkklainen 2003). Park *et al.* (2010) have pointed out that the primary application of RFID is related to the identification, location and data accumulation.

Mehrjerdi (2010) argues that radio frequency identification technology is considered one of the ten most influential 21st century business technologies designed for supply chain process management. The same is confirmed by Li and Visichiaus (2006), arguing that the use of RFID technologies include the increased visibility of inventory and assets at the certain functional areas of the supply chain, reduced stock levels, improved customer satisfaction, reduced absence of preferred goods in stock, increased effectiveness, reduced labour costs, enhanced cooperation and planning, improved information dissemination and increased sales revenue and security guarantees. According to Kim *et al.* (2008), RFID allows to transfer information on time thus reducing possible information errors. Angeles (2005), Li et al. (2006), Park *et al.* (2010) and Mehrjerdi (2010) agree with that, emphasising the fact that effective information sharing and timely data transferring enable better control of supply chain processes. Curtinas *et al.* (2007) have distinguished the following four possible categories of RFID employment: business-to-business (B2B) logistics, internal operations, business-to-customer (B2C) marketing and sales, and business-to-business (B2B) service. At the same time, Wyld (2006) and Smith (2005) have carried out the research on applying RFID technologies and resulted in the following three categories: RFID application, its impact and significance. According to Li *et al.* (2006), in order to get the maximum benefit out of RFID for the supply chain, business partners around the world should use RFID tags, scanners and scanning frequencies of the same standard so that they could be used throughout the entire supply chain. The author has also claimed that the standardization process preconditions the lower costs of the development and production of RFID tags, scanners, software and hardware.

RFID tag is a key component of the RFID technology. It consists of an antenna and a chip with a processor. Using the antenna, signals are being sent and received; and the chip is required for the storage of the information, that is the unique electronic product code (EPC) for the object, to which a tag is attached, identification. Such tags come in various shapes and sizes as well as types and options. Applying the latest technologies, the tags barely visible to the naked eye, which are employed in medical and biological research, are being developed (Reyes *et al.* 2007; Ranky 2006).

RFID tags might have various characteristics, depending on the specific needs of their employment. One of the key characteristics is their different operating frequency in the range of radio waves, which is from 125 kHz (low frequency) to 5,8 GHz (microwave frequency) (Bean 2006). The process of the standardization of RFID technology is mainly regulated by the following organizations: the International Standard Organization (ISO) and the International Electronic Product Code Organization (EPC Global). ISO focuses on the development of RFID standards (Smart *et al.* 2010) and EPC Global aims at the development of the electronic product code standards and the employment of radio frequency identification technologies in the global supply chain (Struker, Gille 2010).

Standardization is one of the problems of RFID technologies as RFID technologies are not completely standardized. Different regions are using different standards for RFID tags. Major users of RFID technologies, such as "Wal-Mart", "Tesco" and their larger suppliers, such as "Proctor and Gamble", "Nestle" and etc., support EPC Global in order to standardize the entire RFID activity (Smart *et al.* 2010). In 2006, Vijayaraman and Osyk have carried out a survey which estimated that only 15% of the users of RFID technologies were the members of EPC Global and about 39% were going to become.

As world practice shows, electronic product code is increasingly replacing European Article Numbering (EAN) code used for barcode labels; however, in the near future, the barcode will not be pushed out of the international product marking (Bose, Lam 2009). EPC, compared to EAN, has not just a serial number that allows identification of a unique product but also both manufacturer and product classification numbers (Rida *et al.* 2010).

3. RFID in supply chain

RFID and EPC, and their implementation, causes, limitations and benefits concerning the supply chain, are widely discussed in the scientific literature (Smart *et al.* 2010; Bottani, Rizzi 2008; Hansen, Gillert 2008; Kim *et al.* 2008; Prater *et al.* 2005).

Juban, Wyld (2004) have stated that the main reason for the employment of RFID is the capability of the tag to provide more information about a product in comparison to a traditional barcode. Vijayaraman and Osyk (2006) have pointed out that the key advantage of RFID is the possibility of sharing information with business partners, cooperating in reserves management, planning and forecasting. They have also emphasised the effectiveness of RFID technologies, in comparison to barcode, considering the decreased number of errors related to human factor. According to Wamba et al. (2008), RFID technologies and EPC network, taking into consideration the effectively improved processes of cargo consignment, receipt, storage and recruitment, are particularly useful to business-to-business (B2B) commerce. Their opinion is based on the results of the empirical research during which the logistics supply chains of the interrelated companies were investigated. Bottani and Rizzi (2008), focusing on labour efficiency, on the example of the supply chain of the fast moving consumer goods, have proven the fact that both a manufacturer and a retailer applying RFID technologies could achieve an effective reduction in the resources of labour efficiency. Li *et al.* (2010), Li and Visich (2006) have emphasised the potential of applying RFID for the reduction of the level of the accumulated reserves, the enhancement of security, the opportunities for cargo tracking, the dissemination and effectiveness of information and the retail trade, where RFID could be used for the control of the amount of products on the store shelves. Whereas, Mehrjerdy (2010) has paid a particular attention to such benefits of RFID as tracking speed and accuracy of pallets, crates and containers management, effective management of the stock level, cost reductions of the operation management and increased visibility of inventory and assets. Tajima (2007) has analysed the strategic value of RFID in supply chain and distinguished 15 advantages of radio frequency identification technologies (Table 1) divided into two groups.

In the first group, the advantages which benefits are tangible throughout the entire supply chain are presented; i.e., reduction of disappearances/losses, better management of the materials, increased data accuracy, faster management of the exceptional cases and better information exchange.

Table 1. Description of the Advantages of RFID (created by authors according: Tajima 2007; Mehrjerdi 2009)

Advantages	Brief Description
Reduction of disappearances/losses	Spoilage; theft
Production management	Lower labour costs; increasing efficiency
Increased data accuracy	Accuracy of the information
Faster management of the exceptional cases	Operative management of the exceptional cases
Better information exchange	Timely information
Production monitoring	Stock-level control
Quality control	Quality control during the process of manufacture
Guaranteed continuous production	Steady supply; management of the materials
Management of the material flow	Management of the materials and reserves
The use of location	Warehouse space utilization
Assets management	Efficient use of the property
Distribution of the production	Tracking the material flow
Customer service	Identification of customer service standards
After-sales service	Identification of after-sales service rates
Reduction of the reserves	Identification and control of the reserves

In the second group, the benefits of RFID are grouped according to the main participants of the logistics supply chain:

1) manufacturer and supplier (i.e., production monitoring; quality control; supply);

2) logistics provider and logistics/distribution centre (i.e., material flow management; space utilization; assets management);

3) retail sales representative (i.e., products management on the shelves; customer service; after-sales service; reduction of the reserves).

Considering Bottani *et al.* (2009) point that the maximum benefits of RFID technologies are achieved by developing the information management system, it is important to make it available to all supply chain participants that would lead to timely decision-making and real-time problem-solving.

4. RFID technology implementation risks

Researchers (Smith 2005; Li *et al.* 2006; Tajima 2007; Shih *et al.* 2008; Li *et al.* 2009; Pedroso *et al.* 2010; Vijayaraman, Osyk 2006; Hansen, Gillert

2008; Struker, Gille 2010), dealing with RFID applying opportunities, have presented not just the advantages of the technology but also the factors slowing the spread of RFID down (Table 2).

Table 2. Risk Factors Related to Applying RFID

Author	Barriers, Risk Factors
Smith (2005)	Costs; security issues; standards.
Li and Visich (2006)	High implementation costs; investment payback; data integration and management; technical problems; lack of standardization; lack of knowledge; security.
Vijayaraman and Osyk (2006)	Lack of standards; costs; integration of the systems; security/privacy.
Tajima (2007)	Investment payback; technical risks; entrenchment of the barcode; security/privacy issues.
Hansen, Gillert (2008)	Data protection; lack of effectiveness; implementation costs; security.
Shih *et al.* (2008)	Effectiveness of the processes; financial risks; organizational contexts; technological characteristics.
Li *et al.* (2009)	Lack of knowledge; technological barriers; costs; lack of real examples in business.
Struker and Gille (2010)	Integration; costs; technical risks; security/privacy.
Pedroso *et al.* (2010)	Costs; investment payback; evaluation of effectiveness; lack of knowledge.

Considering the risks the authors have mentioned (Table 2), the following barriers slowing the process of the implementation of RFID technologies down could be distinguished: investment payback; high investment costs; security and privacy; lack of knowledge; technical barriers.

The results of the researches carried out by Li *et al.* (2010) have shown that, despite the possibilities and the potential of radio frequency technologies, in supply chain management, many companies avoid implementing or even considering the possible implementation of these technologies in the future. The authors have investigated the companies which have a potential to implement RFID technologies and come to a conclusion that the main reason of avoiding implementing RFID is the lack of knowledge and information. Companies, lacking the clear understanding of RFID technologies, do not consider the implementation of these systems due to the fear of a large initial investment, their effectiveness and benefits.

Smart *et al.* (2010) have identified the key factors slowing the process of RFID development down. The main problem, joining a number of these factors together, is the costs, including the hardware and software costs, integration of the systems into existing ones, changes in infrastructure, staff training, and system maintenance and the high cost of RFID tags. Although the yearly costs of RFID tags are continually decreasing, the employment of RFID technologies remains several tens of times more expensive than of the barcode (Struker, Gille 2010). Considering this fact, it could be stated that the barcode is one of the factors slowing the employment of RFID technologies down. According to Tajima (2007), one of the advantages of the barcode is the fact that it is inexpensive, standardized and, in most cases, responding to consumer needs; therefore, fairly expensive RFID technologies experience the difficulties with displacing it from the market.

Another problem related to the employment of RFID technologies is the privacy issue as there are fears that RFID technologies could be used for tracking people and gathering information about them. However, Bose and Lam (2009) have contradicted these opinion, stating that the employment of RFID technologies in supply chain is not connected with the consumer up to the point of the sale; therefore, there is no threat to personal privacy. However, Dobson and Todd (2006) have argued that the employment of RFID might affect a person's privacy after the sale. Wu *et al.* (2006) have a similar view to this problem, claiming that the customer could be monitored due to the radio signals the product emits if the RFID tag is not removed after the sale. The collected data could be used for marketing purposes; customer needs analysis, or even criminal activity. In order to reduce privacy violations, there should be implemented such measures as legislation, code of ethics and consumer's behaviour determining means; i.e., education and legal restrictions (Tajima 2007).

Summing up the factors slowing the process of the spread of RFID technologies down, it could be claimed that the main factors are related to the costs and the lack of knowledge. Other factors, in some way, are related to the factors mentioned above as while the price of RFID technologies is sufficiently high, and the perception is quite low,

the process of the improvement of the indicators of all other factors will be proceeding slowly.

5. Applying RFID technologies at Lithuanian companies

In order to examine the situation of RFID employment in Lithuania, in 2010, a survey, in which 300 respondents have participated, was carried out. In this survey, a questionnaire method was applied. The questionnaire included general questions, i.e., the respondents representation of the company, position held, activities performed, number of employees, as well as questions related to the employment of RFID technologies.

The results have shown that 41 % of the respondents were managers (managing directors) of the company, its department or division; 24 % were specialists (engineers, technicians); 22 % were managers; 8 % were lower-ranking employees; and 6 % denied specifying their positions.

According to the type of the company's activity, there was the following distribution: 57 % were manufacturing companies; 29 % were wholesale trade companies; 22 % were transport companies; 16 % were retail trade, warehousing and service-providing companies; 8 % were companies providing the third part logistics (3PL) services; 6 % were forwarding companies; 4 % were parcel service companies; and 6 % were representing ship agency, postal and communications regulatory services companies (the respondents were allowed to specify more than one activity) (Fig.1).
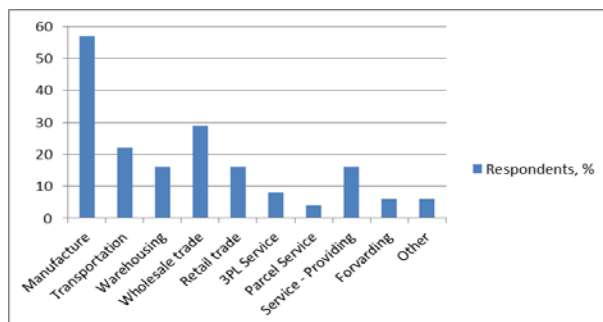

Fig. 1. Type of company

22 % of the respondents have indicated that they represent the company that has from 10 to 50 employees; 20 % represented the company that has from 50 to 100 employees; 33 % represented the company that has from 100 to 250 employees; and 25 % have indicated that they belong to a large company that has more than 250 employees (see Fig.2).

Of all the companies analysed, 15 % have indicated that, in their company, RFID technologies are implemented and applied; among them: 5 %

are using RFID technologies to control the entry into the territory or the exit from it; 5 % are applying RFID technologies to the processes starting from tracking the residual raw materials during the manufacturing process and among different manufacturing departments and ending with cargo recruitment and transportation; and the remaining 5 % of the respondents are using RFID technologies in such processes as cargo recruitment, transportation and real-time tracking.
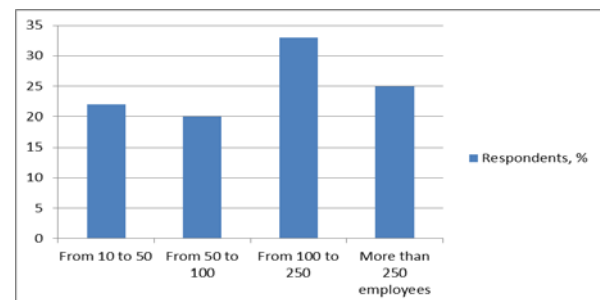

Fig. 2. Size of companies

The main factors that affected the respondents' decision to implement RFID technologies in their company were the following: time-saving (63 %); more effective use of human and material resources (50 %); and the innovative policy of the company (38 %). Responding to this question, the respondents were allowed to indicate multiple answers.

The results of the investigation of the influence RFID technologies have on quality have shown that the employment of these technologies preconditions the decrease of the errors related to human factor / factory defects and the acceleration of manufacturing processes (37.5 %).

The respondents who have indicated that, in their companies, RFID technologies are not implemented, have mentioned that the implementation of them would lead to the increase of effectiveness in their companies (46 %); 23 % of the respondents have stated that the situation would remain the same; and about 31 % of the respondents have answered that they do not have a clear opinion considering these question.

During the survey, it was tried to identify the reasons preventing the implementation of RFID technologies in Lithuanian companies the respondents represented (responding to this question, it was allowed to select more than one answer). About 42 % of the respondents have identified the low distribution of these technologies in Lithuania as the main barrier; 38 % have mentioned high initial investment and lack of knowledge concerning possible RFID applying; 31 % have mentioned high prices of RFID tags; 27 % have emphasised the lack of information concerning the imple-

mented projects; 23 % have stated that their companies do not have the need to implement RFID technologies; and 15 % of the respondents have declared that the prospects of RFID technologies are not clear and the fact that there is a large supply of cheap labour on market is slowing the process of innovation down.

What is more, 15 % of the respondents are not aware of the reasons preventing the implementation of RFID technologies in their companies; 8 % have mentioned a long payback period; and 4 % of the respondents believe that there might be a lack of competence of a company's management.

The survey was also aimed at identifying the processes the execution of which has the largest RFID technology demand (responding to this question, it was allowed to select more than one answer).

Most of the respondents (60 %) have indicated that RFID technologies could be useful for the storage processes; 55 % of the participants of the survey believe that RFID might be useful for the preparation of the reports and management of the documents; 45 % have mentioned the accounting and movement of the residues of raw materials and goods; 35 % of the respondents have stated that RFID could be useful for accepting and crediting cargo, feedstock or goods as well as manufacturing and loading processes; 30 % of the respondents believe RFID could be helpful in recruiting the parcels; 25 % have mentioned packaging, labelling and transportation processes; 20 % have emphasised the processes of transportation at different manufacturing phases and departments and accounting of cargo and inventory; 10 % of the respondents believe RFID could be helpful in preventing theft; and 5 % have pointed out that RFID technologies might be helpful in the processes of ordering feedstock and goods and real-time cargo tracking.

The results of the survey have shown that such reasons as the need for time-saving and attempts to use human and material resources more effectively have the greatest influence on the implementation of RFID systems. A modern and receptive to innovation company's policy has also contributed to the implementation of RFID systems.

It could be stated that the vast majority (88 %) of the companies implemented RFID are able to completely or partly achieve their objectives. 7 % of the respondents have mentioned that the implementation of RFID technologies has paid off within the first two years; the remaining 5 % of the respondents have not provide any data concerning the technology payback. However, even 23 % of the respondents have confirmed the fact that RFID

has facilitated the processes of documentation and accounting management. This is a striking example of the benefits of automated RFID technologies. 70 % of the respondents have declared that the implementation of RFID has not affected the cost of the product.

As the results of the survey have shown, the companies' implemented RFID technologies are using them only at the level of a single organization; thus, the total potential of this technology is not being used in supply chain.

In order to evaluate potential users of RFID technology, it might be useful to mention the fact that 46% of them have considered such possibility and believe that these technologies could be beneficial to their activity. The remaining 54 % of the respondents are sure that RFID could not improve their business performance.

The highest need for RFID technologies in Lithuanian companies appears to be found in the following areas: warehousing; reporting and documentation; accounting of residues of raw materials and goods; manufacturing; cargo accepting and shipping.

Processes that, according to the respondents, experience the greatest need for RFID technologies in their companies belong to the most important areas of functional activity of supply chain. It could be assumed that the beginning of the process of the implementation of RFID technologies at a particular area of the activity of supply chain could lead to their further integration into the global supply chain management system.

The analysis of the potential consumers of RFID technologies has revealed the following main reasons affecting the slow implementation of RFID in the companies: low distribution of RFID technologies; high initial investment; lack of knowledge concerning possible RFID applying; high prices of RFID tags; lack of information concerning the implemented projects.

The results of this survey have coincided with the results of the scientific researches carried out in other countries, where the fact that the implementation of RFID technology is mostly slowed down due to such reasons as high investment rates, high tag price, lack of information concerning the projects implemented and RFID technologies in general and, finally, the cautious approach of the companies to innovation and their delay to start using technologies, until they have not been used in the practice of other companies, has been proved.

6. Conclusions

The process of business globalization in the world market is influencing the development of the processes of supply chain management, the increase of the integration of business processes, the improvement of the management of material and informational flows, the increase of efficiency and competitiveness and the reduction of costs.

One of the supply chain management tools is radio frequency identification technology (RFID), which allows to integrate and coordinate all supply chain activities: from feedstock to the final product's sale and after-sales service; thus improving the visibility of supply chain and the management of real-time information and material flow.

The following RFID advantages were identified after such processes as cargo acceptance, transferring to storage, collecting and shipping have been evaluated considering the differences between their execution in usual manner and applying RFID technologies: the reduction of time, labour force, storage space requirements, errors related to human factor; and the improvement of work accuracy and effectiveness as well as information dissemination.

Survey results have shown that 27 % of the respondents are familiarised with RFID technologies (15 % have implemented them) and 63 % have heard about them but are not aware of their peculiarities.

The reduction of labour costs (25 %), reserves (50 %) and loss of cargo or products (18 %) was identified as the key benefit of RFID technology. Moreover, the processes of cargo reception, recruitment and shipping are shortened to 80 %, information accuracy becomes close to 100 % and the absence of the preferred goods in stock is reduced to 26 %.

The main factors slowing the process of the spread of RFID technologies in Lithuania down are: lack of information concerning RFID technology, its possible applying and the projects implemented; and high costs related to the implementation of the technologies and the price of RFID tags.

The results of the research have shown that Lithuanian companies are poorly familiarised with RFID technologies and the opportunities they open; therefore, their effectiveness and cost are being treated in an inadequate way.

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