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FACTORS INFLUENCING THE DECISION TO IMPLEMENT AN RFID SYSTEM

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ABSTRACT. **Background:** The RFID (Radio Frequency IDentification) stands for a modern technique of wireless identification of objects, which at the present stage of development is frequently used in automated processes in various sectors of economic activity. Today, as technology more and more often surprises us with various solutions, one must constantly follow and invest in new technologies to stay afloat on the market and not fall behind. RFID technology is increasingly applied and implemented in businesses. Unfortunately, there are not many publications on the factors which influence the choice and implementation of new solutions in businesses. The purpose of this article is to identify factors which affect decisions in the process of implementing an RFID system.

Methods: A literature review was performed concerning the implementation of RFID systems in businesses and factors which cause companies to introduce the new identification system. Questionnaire-based surveys were administered in 203 businesses operating on national and international market. Questions were asked about the motivation behind implementing new technologies. Statistical tests (chi square Pearson and analysis of variance (ANOVA)) as well as factor analysis were used in the study. It was also verified if business size, area of operations, introducing innovation, ownership of an identification system, participation of foreign capital and being part of a cluster had any effect on the assessment of factors which influence the purchase of an RFID system.

Results: The findings suggest that for most entrepreneurs the key factor is streamlining the sales, storage and transport processes. In certain cases, such as micro-enterprises, the cost of system implementation is seen as the most significant factor. Socio-economic characteristics also affect the evaluation of the factors.

Conclusion: The analysis provides manufacturers of RFID technologies with information on the expectations of the consumers and what motivates them in their decision to purchase an RFID system. The more capabilities offered by the system, the more it is desirable; the cost of purchase and implementation of the new technology is also quite salient.

Key words: RFID system, businesses, logistics, warehouse, transportation system.

INTRODUCTION

The acronym RFID (Radio Frequency IDentification) stands for a modern technique of wireless identification of objects [Finkenzeller, 2010], which at the present stage of development is frequently used in automated processes in various sectors of economic activity. Today, as technology more and more often surprises us with various solutions, one must constantly follow and invest in new technologies to stay afloat on the market and not fall behind. One of the key

skills and a prerequisite for survival is the ability to effectively respond to changes in the environment – the so-called 'agile organisation'. Efficient logistics process management is based on the use of modern IT tools as well as mobile technologies. State-of-the-art information technology tools designed for effective and successful logistics process management are helpful in this respect. Technological advances in the design, construction and use operation of IT management systems is a basic pre-condition for the development of logistics. The fastest possible flow of information in the most

appropriate form helps achieve both decision-making and performance objectives. Undoubtedly, fast and accurate information forms the basis of an optimum logistics system [Palonka, 2007].

Due to the complexity of the logistics process and the multitude of actions requiring reciprocal coordination, organizations strive to create and effectively use logistics information systems. Their main role is to acquire, gather and process data and to make them available for application in managerial decisions. The systems enable us to monitor parameters of logistics customer service such as the size of delivery, the order completion cycle, the percentage of delayed orders, the percentage of complaints and refunds, rebates/discounts, payment conditions and the cost of delivery. The use of modern technologies (GPS, GSM, RFID) e.g. to track a fleet of vehicles with cargo, in combination with advanced logistics information systems, significantly increases the effectiveness of a logistics system.

RADIO FREQUENCY IDENTIFICATION (RFID) – PRINCIPLE OF OPERATIONS

RFID offers high reliability and functionality in comparison to bar code technology. Indeed, it is one of the most dynamically developing automatic object identification techniques. RFID dates back to the 1940s when British Air Force used RFID – like technology in World War II to distinguish between enemy and friendly aircraft [Asif and Mandivwalla, 2005]. The theory of RFID was first explained in 1948 in a conference paper entitled "Communication by Means of Reflected Power" and the first patent for RFID was filed by Charles Walton in 1973 [Takahashi, 2004]. The technology enables wireless transmission and reception of information coded in radio labels [Straub, Rai et al., 2004]. A radio frequency identification system stores information in transceivers, and then reads such information in an automated way, at suitable time and place. Information contained in an RFID tag may describe relevant parts on the manufacturing line, goods in transport, location of objects or may be used to identify vehicles, animals or people. By appending the tag with additional information, the application may be extended by capabilities supporting its operation to include specific information about the object labelled by the tag. An advantage is the lack of direct visibility of the two components, unlike e.g. in the case of bar code readouts. Information is acquired wirelessly as far as tens of metres from the reader [Długosz, 2009]. The entire process operates through radio transmission – immediately, automatically and without direct physical contact. The structure of RFID systems may vary substantially depending on their purpose.

A radio identification system contains software and hardware layers. The software layer includes programmes which manage system operation, whereas the hardware layer is composed of a read/write device, its antenna and electronic radio identifiers designed for tagging objects (Fig. 1).
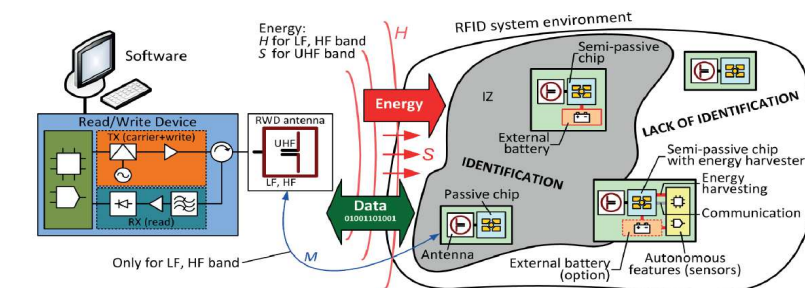
Source: Jankowski et.al., 2016

Fig. 1. A general flow chart of a UHF band RFID system

The most common passive design contains a chip and an antenna connected to it. The design may also feature a replaceable or non-replaceable power source (typically a disposable lithium battery), whose main function is to supply power to the chip. This function increases the size of the area of correct operation. RFID identifiers incorporating a power source are called semi-passive or active tags. In modern designs of the chips (with wired alongside wireless interface), battery power can be used for making measurements of physical properties (e.g. humidity [Lee et al., 2011], temperature [Cartasegna et al., 2010, Opera et al., 2009], light intensity [Cartasegna et al., 2010], pressure [Yang et al., 2007], acceleration [Tani et al., 2007], gas concentration [Opera et al., 2009]), structural deformation [Zhang et al., 2015] the results of which may be stored in the tag's internal memory. Those functions ensure the autonomous operation of a semi-passive identifier and are performed without the read/write device. Continuous operation of the read/write device (RWD) is essential for maintaining the communication process in the RFID system. The additional source of power for semi-passive chips does not enable them to automatically initiate their transmission systems, which means that the antenna and the RFID identifier do not emit an EM field like the one in SRDs (Short Range Devices). Such properties diversify semi-passive RFID identifiers from classic, active SRDs.

Table 1. Advantages and disadvantages of modern RFID technologies

Advantages	Disadvantages
• the capability of simultaneous read and write operations on multiple labels • information is exchange via radio, thanks to which direct visibility between the identifier (tag or transponder) and the reader's antenna (scanner) is not required • packaging is not an obstacle for write or read operation – labels may be placed on the products, thus providing a greater reading range • data stored in the label can be updated – over 100 000 times • high-speed transmission between labels and readers; the tag does not need to be visible during the readout • incomparably greater safety thanks to the ability to encrypt data • the possibility of using information in various applications • dirt- and weather-resistant radio tags operate in a broad temperature range and are virtually immune to environmental conditions (snow, ice, mud, rain, vibrations etc.), enabling identification in locations which are hard to reach • multiple overwrite capability [Rundh, 2008] • considerably shorter stock-taking time • full control over stock/production levels in real time • RFID offers the lowest error rate among all automatic identification technologies • material and asset tracking in the supply chain leading to lower stock levels – tracing product theft locations • withholding the delivery of goods should they be dispatched in the incorrect direction – preventing the import of fake products – increased control over product recall processes (e.g. removal of outdated product from retail shelves) (Rutkowski 2003) • the possibility of writing more information about products and reading multiple tags at the same time • the possibility to analyse the conditions and the environment in which the product was kept	• price • health hazard • risk of redundancies (increased unemployment) • data security, read speed – products with passive tags must move slowly through reader gates • issues with reading tags in close proximity to one another • privacy protection (privacy violation) – the use of the technology by criminal groups (identity theft by scanning a building and objects located within, replacing labels of expensive products with those of cheap ones) • the effect of radiation on the human body, risk of cancer, risk of interference with the operation of medical equipment (pacemakers) • the price of tags and readers

Source: own work

Additional components of the systems may include: label printers capable of coding RFID tags (frequently classified as readers) as well as sensors, actuators and notifiers, which are used to monitor and control the system.

Commercial applications make use of radio frequencies standardized for specific geographic regions (different frequency ranges apply in the US and different ones in Europe) RFID systems generate and radiate electromagnetic waves, and as such are

classified according to law as radio systems. Their operation must not interfere with that of other systems. This requires strict adherence to permissible frequency ranges.

The benefits and drawbacks of the introduction of new technologies are listed in Table 1.

The RFID technology allows its users to optimize the operation of various systems, hence its application in many sectors of economy. The technology makes it possible to track articles in production as well as to control its flow or optimize activities related to the supply of components and their storage. Most companies which implement RFID belong to the automotive, consumer goods, logistics and transport industries. Sectors that demonstrate the highest level of the implementation of radio identification techniques include the production of electronics, construction materials and oil processing. There are several systems in which the RFID technology is applied, including: work time registration systems, an Access Control System, loyalty systems and e-wallets and logistics systems and supply chain management. Locations and areas in which the RFID technology is typically used include: warehousing, mines, health care, ski slopes, animal identification and land and air transport. In addition, the method is used in:

- motorway toll collection and traffic flow improvement (E-ZPass system is used in the US),
- automatic identification of the means of railway transport (China) [Lai et al., 2005],
- shipment monitoring in pharmaceutical industry designed by DHL and IBM to monitor temperature during transport,
- a system for positioning buses over parking space [Rodier et al., 2011],
- vehicle traffic control process management in loading and unloading centres,
- e-ticket system in public transport (pre-paid city cards),
- lorry and bus tyre monitoring (Goodyear, Michelin),
- container, pallet, cylinder, tank etc. identification and tracking,
- luggage and parcel sorting and identification at airports (Delta Airlines) [Dobrzański and Dobrzańska, 2012],
- courier deliveries [Xiao-dan, et al., 2006]
- temperature monitoring in aircraft during re-entry from orbit [Milos et al., 2001],
- German forestry company is using RFID for its log tracking application [Dines, 2004].

FACTORS INFLUENCING THE DECISION TO PURCHASE AN RFID SYSTEM – STUDY RESULTS

Many firms are reluctant to adopt RFID as a part of their own systems. This stems mainly from the cost that businesses would incur in the implementation of a new system [Reyes et al., 2008]. But also the main reasons are: uncertainty with regard to the requirements and capabilities of the technology itself and uncertainty with regard to the effects of the technology on inter-organizational relationships [Cannon et al., 2008]. Since the big bang of RFID, a number of empirical studies have been constructed to investigate the adoption, benefits and challenges of RFID implementation [Reyes et al., 2016]. For companies either considering and implementing RFID, internal reasons for deploying RFID included better inventory and supply chain visibility, efficiency gains, labour efficiency asset tracking and out of stock reduction. Sometimes respondents considering or implementing were asked to rate the importance of 30 factors that might motivate an organization to implement RFID, with the top three categories being inventory management, competitive decisions and cost reduction in processes [Li et al., 2010]. Studies on factors affecting the decision to introduce new object identification technologies [Reyes et al., 2016] tested the following hypotheses: a higher level of external and internal drivers, top and middle level management, lead to a higher level of RFID adoption stage, a higher level of costs issues, lack of understanding and technical issues lead to a lower level of RFID adoption stage.

Other studies point to both external and internal environment as the factor creating conditions favourable for system implementation. An internal implementation environment will create conditions that lead to an effective implementation of the RFID program when an organization has: cross functional terms dedicated to the RFID implementation; top management support for the program and existing technical knowledge related to RFID technology. Also an external implementation environment will increase the follower firm's commitment to implementing the RFID program when follower's relationship with the initiator exhibits: flexibility; information exchange and solidarity [Fries et al., 2010]. In 2015 a study was carried out in the group of 203 entrepreneurs concerning factors which influence the decision to purchase and implement an RFID system in Polish businesses. The survey was designed to gather a broad range of information on the micro-environment and internal conditions of business operations, individual conditions of making investment decisions and the macro-environment of the business.

METHODOLOGY

The research was carried out among entrepreneurs and was based on a questionnaire which included questions on various areas related to the introduction of RFID for businesses, and above for all macro-environment and internal conditions of the company and symptoms of conditions making investment decisions. For the research the statistical tests were used to allow for the indication of dependency and variations in the assessment factors for managers. The study used the ANOVA test by Kruskall-Wallis, which allows to explore whether there are statistically significant differences in the quantitative characteristics of respondents in the division into the quality ones. This test is an equivalent of a one-way analysis of variance but the assumptions concerning the normal distribution of the quantitative characteristic and constancy of variance do not need to be met. There was also used a factor analysis which allowed grouping of factors in some blocks, which are responsible for the areas related to the decision on the introduction of RFID in companies.

CHARACTERISTICS OF THE TEST GROUP

Most of those surveyed worked for a limited-liability company (47%). The majority (34%) of the surveyed businesses were large enterprises. Most companies had international area of operations (47%). Manufacturing businesses prevailed in number (34%). Slightly more than a half had foreign capital in their shares (41%) with only 10% associated in clusters (IT, Dolina Lotnicza, MPT). Mean pay in a business usually approximated the national average (47%). On average, the businesses surveyed have been present on the market for 21 years. The youngest company was established a year ago, while the oldest 95 years ago. Most often businesses have been present on the market for 20 years (19 such companies in total). As many as 62% entrepreneurs declared that they introduce innovations in their businesses.

Table 2. Characteristics of the test group

Features	Category	Quantity	Per cent	Features	Category	Quantity	Per cent
Legal form	limited liability company	94	47%	Participation in a cluster	yes	20	10%
	joint stock company	36	18%		no	179	90%
	private partnership	20	10%	Size of business	micro	28	14%
	registered partnership	18	9%		small	51	26%
	other	33	16%		medium	52	26%
Mean salary in the business	below national average	62	31%		large	68	34%
	approximating national average	94	47%	Area of operations	local	39	19%
	exceeding national average	46	23%		regional	37	18%
Business sector	manufacturing	69	34%		national	31	15%
	services	47	23%		international	95	47%
	commerce	56	28%	Participation of foreign capital	yes	83	41%
	mixed	29	14%		no	118	59%

Source: own work

Entrepreneurs were asked to rate 33 factors which may motivate the purchase and implementation of an RFID system with API in the company (on a scale from 0 to 3, where 0 means no influence and 3 large influence). For the above factors, mean ratings were calculated, as shown in Figure 2. The results suggest that streamlining sales, warehousing, transport and administrative processes are rated highest among the entrepreneurs (2.43). Other important factors included: cost of implementation (2.35), identifier quality (2.33) and identifier price (2.21). Special capabilities such as pressure, vibration, stress or lighting measurement were least important for entrepreneurs.
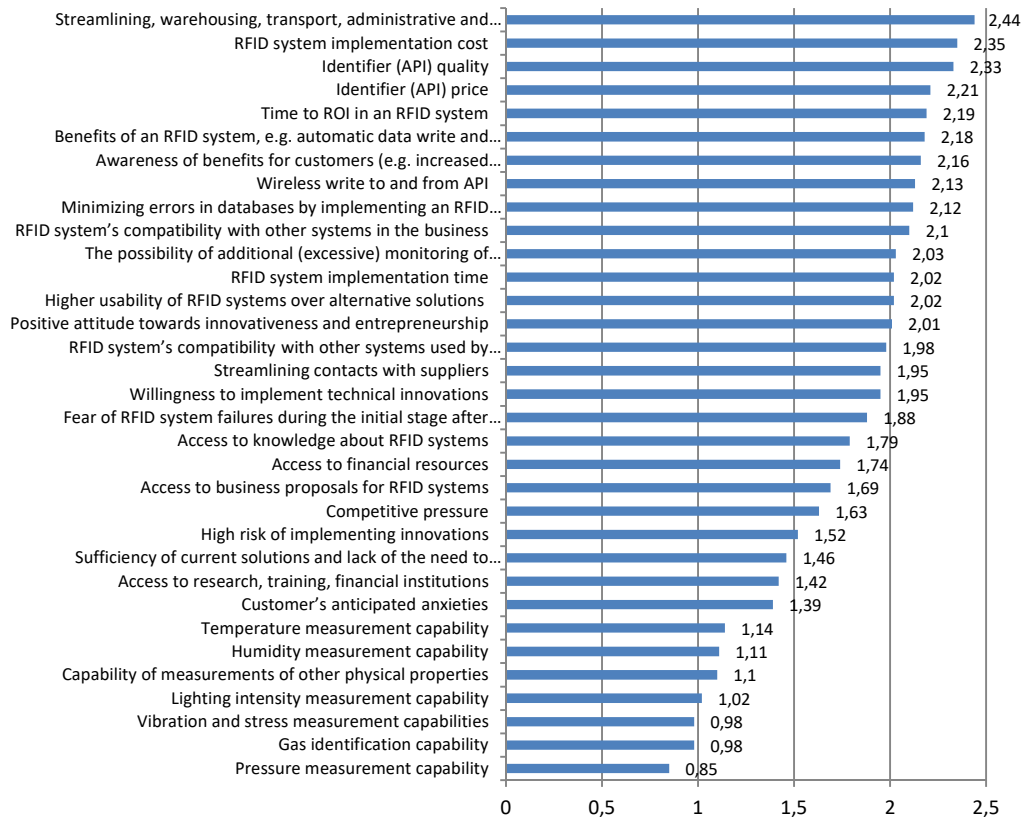
Source: own work

Fig. 2. Factors which motivate the purchase and implementation of an RFID system with API – mean ratings by entrepreneurs

The selection of factors influencing the decision to purchase the system may be affected by various conditions. They may be perceived differently by innovative businesses (businesses which introduce innovation in their operations) as opposed to those which do not implement innovation. A similar situation may occur in reference to whether a business already has an identification system. It was therefore necessary to verify whether innovation, ownership of an identification system, size of the business, area of operations or being a part of a cluster (IT or other) had an impact on the assessment of the significance of the factor and if there are any differences across groups of surveyed enterprises in terms of the ratings awarded to factors influencing the decision to introduce an RFID system.

There was verified if innovation in business had any connection with the rating of each of the factors with potential influence on the purchase of an RFID system featuring API. Approximately 62% entrepreneurs stated that they introduced innovation in their companies. The most important factor in both groups was streamlining warehousing, transport and administrative processes. The second most

important factor among entrepreneurs who declared to be innovative was the quality of the identifier and advantages of the RFID system, whereas for non-innovative entrepreneurs it was the cost of implementation and the price of the system. Differences in factor ratings were present in the case of the advantages of the RFID system (p=0.01484), identifier quality (p=0.0066), implementation time (p=0.0491) and the RFID system's compatibility with other systems (p=0.01487). In each case higher ratings were reported in the group of innovative entrepreneurs (Figure 3).

Being an owner of an RFID system. More than half entrepreneurs, namely 59%, already had an RFID system in their company. It was verified whether being in possession of such a system had any effect on the assessment of the factors. Again, both group indicated streamlining sales, warehousing and transport processes as the most significant factor. Meanwhile, the second place in the group of existing owners of an RFID system was occupied by the quality of an RFID identifier and the advantages of the system. In the group of entrepreneurs who did not own any identification system, the cost of implementation and the price of an RFID identifier ranked second in order of importance. The study verified the areas in which differences between the groups occurred. Statistical test indicated that differences in ratings were present for the assessment of the advantages of an RFID system (p=0.0030), implementation time (p=0.0054), streamlining contacts with suppliers (p=0.0002), high risk of system implementation (p=0.0092), access to financial resources (p=0.0004), access to business proposals for RFID systems (p=0.0010) and the sufficiency of current solutions, and therefore no need to implement an RFID system (p=0.0071). Businesses which already owned an RFID system ranked its advantages and implementation time higher, whereas those which were not in possession of any such system gave higher ratings to streamlining contacts with suppliers, business proposals and the sufficiency of current solutions (Figure 4).
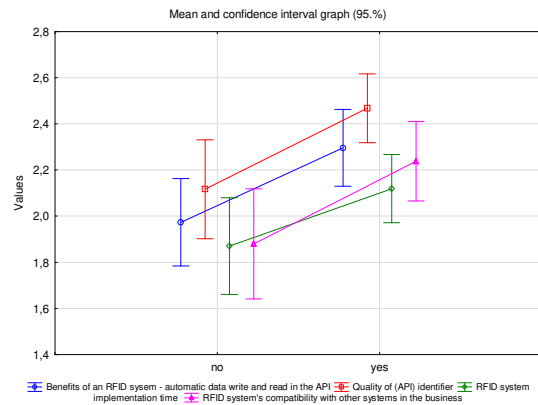
Source: own work

Fig. 3. Mean rating in the group of innovative and non - innovative managers
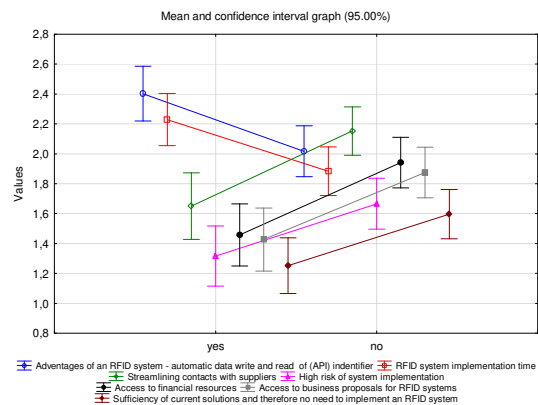
Source: own work

Fig. 4. Mean values in the group of being an owner and non – being an owner of an RFID system

It was verified whether the ranking of factors having an impact on the purchase decision changed with the size of the business. The top ranking factors are shown in Table 3. The most important factor for micro- and medium enterprises was the cost of system implementation, whereas for small and large businesses the key factor was streamlining processes. The size of the business had an effect on the assessment of the RDIF system's compatibility with other systems in the company (p=0.0067). The larger the business, the higher the compatibility rating – starting from micro- (mean value 1.8) to large enterprises (mean value 2.4).

Table 3. Factor ranking by size of business (only top three positions)

	micro	small	medium	large
1	System implementation cost	Process improvements	System implementation cost	Process improvements
2	Time to ROI	Identifier quality	Process improvements	Identifier quality
3	Process improvements	Price of identifier	Identifier quality	System implementation cost

Source: own work

Business sector. The surveyed businesses operate in various sectors; most of them are manufacturers (34%), for whom the most important factor is the cost of implementation and the quality of the identifier. Companies from the service sector expressed similar opinions. There are fewer companies from the commerce sector (28%) and for them process streamlining and the ability to wirelessly write and read multiple pieces of information (e.g. manufacturer, price, weight, quality, service conditions) in the identifier's memory seems to be the key factor. Businesses with mixed operations (commerce/manufacturing/services) reported the quality of the identifier and process streamlining as the most significant. Differences were present in the assessment of four factors. The top rating was reported for the cost of implementation, rated highest by manufacturing companies and lowest by commerce companies (p=0.04147). Access to knowledge about RFID systems ranked highest among service businesses and lowest among mixed-activity companies (p=0.00438). Differences were also noticed in the assessment of the access to business proposals for RFID systems (p=0.01245) and the access to research, training and finance institutions (p=0.01443). Those two factors received highest ratings by service, and the lowest by commerce businesses.

Area of operations. Companies which operated on smaller (local and regional) markets rated streamlining sales, warehousing, transport and administrative processes as top factors, while companies with a large footprint (national and international market) perceived the cost as the most significant (Table 4).

Table 4. Factor ranking by area of operations (only top three positions)

	local	regional	national	international
1	Process improvements	Process improvements	Cost of implementation	Cost of implementation
2	Wireless write & read capability	Enhanced monitoring of business operations	Identifier quality	Process improvements
3	Identifier quality	Identifier quality	Price of identifier	Identifier quality

Source: own work

Differences in ratings by area of operations were present in the case of nine characteristics. The advantages of the system, cost of implementation, willingness to introduce technological innovations, compatibility with other systems and minimizing errors in databases by implementing an RFID system were assessed as the most crucial by companies operating on international market. National companies attach great importance to the access to financial resources and the high risk of innovation. Local companies rank highly the access to research, training and financial institutions (Table 5).

Among factors influencing the decision to purchase an RFID system, businesses with a participation of foreign capital also tended to give the highest priority to streamlining sales, storage, transport, administrative and other processes; the only difference occurred in the willingness to introduce technological innovations (p=0.00662). Companies with foreign capital participation see the willingness to implement technical innovations as more important.

The study also verified if participation in a cluster led to different factor assessments. For members of business clusters (Dolina Lotnicza, IT cluster, MPT Group, UTC) the quality of the RFID identifier was the most important. Businesses outside clusters saw process streamlining as the most significant.

There are also many differences in the ratings awarded to various factors. Companies associated in clusters gave highest ratings to: vibration and stress measurement capabilities (p=0.00345), capability of measurements of other physical properties (p=0.00491), RFID identifier quality (p=0.02657), cost of implementation (p=0.01181) and willingness to introduce technological innovations (p=0.03107). Among businesses which do not belong to a cluster, the highest rating was given to customers' fears (p=0.01325), access to research, training and financial institutions, (p=0.02652), access to knowledge about RFID systems (p=0.0064) and access to business proposals for RFID systems (p=0.01003).

Table 5. ANOVA test results. Factor ratings by area of operations

	local	regional	national	international	p
Advantages of an RFID system	2.21	1.81	2.17	**2.31**	0.045418
RFID system implementation cost	2.31	1.95	2.45	**2.49**	0.006952
RFID system implementation time	2.00	1.59	1.90	**2.23**	0.001610
Willingness to implement technical innovations	2.00	1.59	1.97	**2.07**	0.040529
High risk of implementing innovations	1.72	1.29	**1.83**	1.41	0.034876
Access to financial resources	1.95	1.46	**2.06**	1.65	0.026469
RFID system's compatibility with other systems	2.21	1.65	2.03	**2.25**	0.016714
Access to research, training, financial institutions	**2.00**	1.32	1.24	1.26	0.000322
To minimise errors in databases thanks to RFID system implementation	2.21	1.73	1.97	**2.27**	0.016708

Source: own work
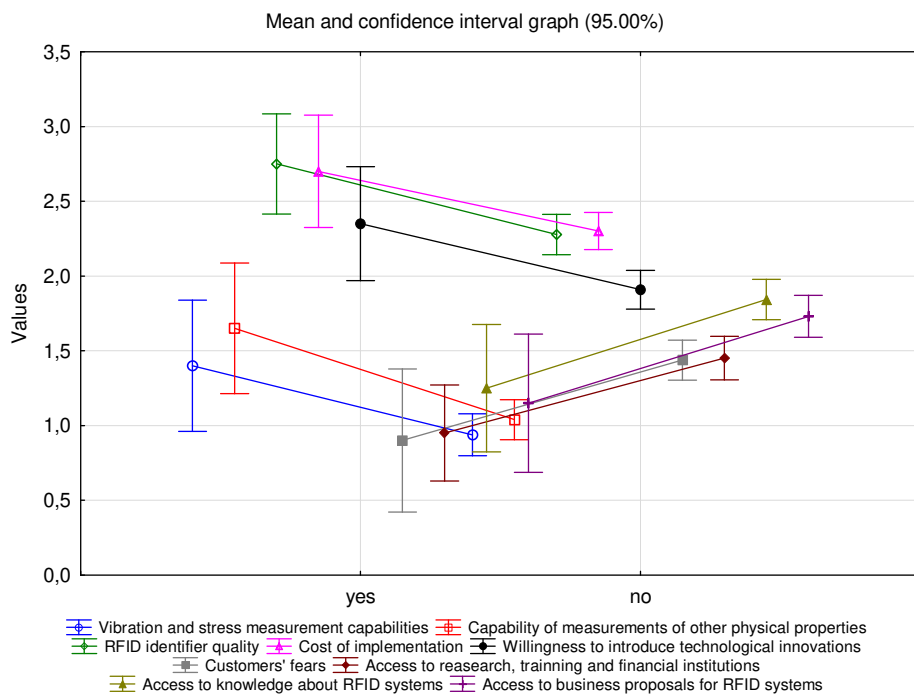
Source: own elaboration

Fig. 5. Mean factor ratings by businesses in and outside clusters

A set of 33 factors which, to a greater or lesser degree, affect the decision to purchase and implement an RFID system in businesses were factors analysed by varimax rotation. The results are shown in Table 6. It can be seen that all items are loaded on their respective factors, with most of loadings greater than 0.60. The cumulative variance explained by the 4 factors is 60%. The tests yielded four factors responsible for: willingness to implement a new system and improve business operations (F1), special measurement capabilities (F2), access to information about the systems and financing (F3) and RFID implementation cost (F4). Relevant factors include areas listed in Table 6.

Table 6. Analysis of factors

	F1	F2	F3	F4
Wireless write and read capability with large data quantities	0.63	0.18	0.12	0.31
Willingness to implement technical innovations	0.61	0.18	0.17	0.25
Improvement of sales, storage, transport and other processes	0.82	0.00	0.02	0.17
Awareness of benefits for customers (e.g. increased customer service quality, satisfaction)	0.76	0.13	0.15	0.10
Minimizing errors in databases by implementing an RFID system	0.65	0.12	0.27	0.27
Temperature measurement capability	0.17	0.75	-0.06	0.12
Pressure measurement capability	0.10	0.80	0.18	0.05
Humidity measurement capability	0.13	0.81	0.05	0.10
Lighting intensity measurement capability	0.00	0.80	0.24	0.04
Gas identification capability	-0.03	0.80	0.23	0.06
Vibration and stress measurement capabilities	0.07	0.73	0.11	-0.03
Capability of measurements of other physical properties	0.21	0.63	0.13	-0.04
Access to financial resources	0.06	0.19	0.52	0.40
Customer's anticipated anxieties	0.06	0.16	0.62	0.04
Access to research, training, financial institutions	0.13	0.18	0.79	0.00
Access to knowledge about RFID systems	0.21	0.06	0.79	-0.02
Access to business proposals for RFID systems	0.16	0.13	0.76	0.17
Price of (API) identifier	0.23	0.13	0.14	0.72
RFID system implementation cost	0.24	0.02	0.06	0.69
RFID system implementation time	0.19	0.00	-0.01	0.78
Time to ROI in an RFID system	0.17	-0.01	0.07	0.83
Output values	**2.75**	**4.31**	**2.82**	**2.79**
Share	**0.131**	**0.205**	**0.134**	**0.133**

Source: own work

Mean ratings for each area were calculated. It was determined that the decision to purchase and implement an RFID system was to the greatest extent influenced by expenses resulting from the implementation of the new system in the company: the price, cost of implementation, time of implementation and time to ROI. Another very important factor was employee's willingness and attitude towards the implementation as well as the advantages of the system. Special capabilities offered by an RFID system ranked the lowest. The assessment of such capabilities was related to the nature of business operations. Commerce companies rated them as lowest, with highest ratings given by mixed-operations businesses. This factor was characterised by the greatest diversity ($\sigma=0{,}74$), (Table 7).

Table 7. Descriptive statistics in groups of factors based on factor analysis

	N	Mean	Median	Std. dev.
Willingness to implement and improve operations	195	2.16	2.4	0.69
Special measurement capabilities	199	1.02	1	0.74
Access to information and financing	195	1.60	1.6	0.70
Implementation-related cost	201	2.19	2.25	0.70

Source: own work

CONCLUSIONS

To maintain their position on the market, economic entities must constantly perfect their own structures, trying to attain the best possible management style, train their managerial staff and seek new solutions and technologies which will boost the development of the business. RFID is one of such solutions – already present on the market and increasing in scope. It allows entrepreneurs to improve and optimize workflows not only in a specific business unit, but also streamlines contacts with business partners. There are highly significant factors which cause a company to introduce a new technology or a new system in their structures. The study reveals that:
– the choice of factors may depend on external and internal environment as well as on the educational status of the managerial staff,
– sales process streamlining and cost of implementation are the most important factors influencing the decision to implement an RFID system,
– innovators rate RFID system advantages, identifier quality, implementation time and compatibility with other systems highly,
– businesses which already own an RFID system rank its advantages and

implementation time higher, whereas those without any such system award higher rating to streamlining contacts with suppliers, business proposals and the sufficiency of current solutions,

- the size of the business has an impact on the assessment of the RDIF system's compatibility with other systems in the company. The larger the company, the higher the compatibility factor's rating,
- the type of business influenced the assessment of implementation cost, access to knowledge about RFID systems, access to business proposals for RFID systems and access to research, training and financial institutions,
- participation of foreign capital diversified the assessment of the willingness to implement technical innovations: companies with foreign capital rated the desire to implement RFID systems higher,
- companies associated in clusters gave highest ratings to vibration and stress measurement capabilities, physical property measurement capabilities, cost of implementation and quality of the RFID system, as well as the willingness to introduce technological innovations. Businesses which do not belong to a cluster awarded highest ratings to customers' fears, access to research, training and financial institutions, access to knowledge about RFID systems and access to business proposals for RFID systems.

Factor analysis allowed to isolate four groups of factors responsible for: willingness to implement a new system and improve business operations, special measurement capabilities, access to information about systems and financing, as well as RFID implementation cost. The factor responsible for system implementation costs proved the most significant.

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CZYNNIKI WPŁYWAJĄCE NA DECYZJĘ O ZAKUPIE I WDROŻENIU SYSTEMU RFID W SEKTORZE MSP

STRESZCZENIE. **Wstęp:** Technologia RFID jest coraz częściej stosowana i wdrażana w przedsiębiorstwach. Celem artykułu jest identyfikacja uwarunkowań decyzyjnych w procesie wdrażania w przedsiębiorstwach systemu RFID (Radio Frequency IDentification).
Metody: Dokonano przeglądu literatury na temat implementacji systemów RFID w przedsiębiorstwach oraz czynników, jakie powodują, że firmy decydują się na wprowadzenie nowego systemu identyfikacji. Przy pomocy ankiety przeprowadzono badania w 203 przedsiębiorstwach działających na rynku krajowym i międzynarodowym pytając, jakie powody skłaniają firmy do wprowadzania nowych technologii. Do badań wykorzystano testy statystyczne (chi kwadrat

Pearsona oraz analizę wariancji ANOVA) i analizę czynnikową. Sprawdzono także czy wielkość przedsiębiorstwa, zasięg działania, wprowadzanie innowacji, posiadanie jakiegokolwiek systemu identyfikacji, rodzaj działalności, udział kapitału zagranicznego oraz udział w klastrze mają wpływ na ocenę czynników decydujących o zakupie systemu RFID.
Wyniki: Badania wskazują, że dla większości przedsiębiorców najważniejszym czynnikiem jest usprawnianie procesów sprzedaży, magazynowania i transportu. W niektórych przypadkach jak w mikroprzedsiębiorstwach najwyżej ocenianym czynnikiem jest koszt wdrożenia systemu. Cechy socjoekonomiczne mają także wpływ na ocenę wskazanych czynników.
Wnioski: Analiza wskazuje producentom technologii RFID jakie oczekiwania posiadają odbiorcy i co nimi kieruje w przypadku decyzji o zakupie systemu RFID. Im więcej możliwości posiada system tym jest bardziej pożądany, niemałe znaczenie mają także koszty zakupu i wdrożenia nowej technologii. W artykule zaprezentowano także wpływ wybranych cech (wielkości przedsiębiorstwa, zakresu działalności itp.) na ocenę wybranych czynników. Wyniki stanowią wkład w identyfikację otoczenia przedsiębiorstwa, które powoduje o decyzjach wprowadzania nowych technologii RFID.

Słowa kluczowe: RFID system, przedsiębiorstwa, logistyka, magazyny, system transportowy

DIE FAKTOREN, DIE DIE ENTSCHEIDUNG FÜR DEN EINKAUF UND DIE IMPLEMENTIERUNG EINES RFID-SYSTEMS IM KMU-SEKTOR BEEINFLUSSEN

ZUSAMMENFASSUNG. Einführung: Die RFID-Technologie wird immer öfter in Unternehmen verwendet und implementiert. Das Ziel dieses Artikels ist es, die Identifizierung der Entscheidungsbedingungen im Prozess der Einführung des RFID-Systems (Radio Frequency IDentification) in Unternehmen darzustellen.
Methoden: Es wurden die Literaturquellen zum Thema der Implementierung von RFID-Systemen in den Unternehmen und die Faktoren überprüft, die es verursachen, dass die Firmen sich für die Einführung der neuen Identifikationssysteme entscheiden. Mit Hilfe eines Fraggenbogens wurden in den 203 Unternehmen entsprechende Untersuchungen durchgeführt – sowohl auf dem Inlands- als auch auf dem Auslandsmarkt – die es zeigen, welche Gründe zu solchen Entscheidungen führen, dass die Firmen neue Technologien einführen. Bei den Untersuchungen wurden die Statistiktests (chi Quadrat von Pearson und die Analyse von ANOVA-Varianz) und die Faktorenanalyse verwendet. Es wurde auch überprüft, ob die Unternehmensgröße, der Wirkungsbereich, die Einführung von Innovationen, die Verfügung über irgendein Identifikationssystem, die Art des Betriebs, ferner der Anteil ausländischen Kapitals und die bestimmte Gruppenteilnahme am wirtschaftlichen Vorhaben einen Einfluss auf den Einkauf des RFID-Systems ausüben.
Ergebnisse: Die Untersuchungen zeigen, dass für die meisten Unternehmen die Verbesserung von Verkaufsprozessen, der Lagerung und des Transports der wichtigste Faktor ist. In einigen Fällen – vor allem in Mikrounternehmen – sind die Einführungskosten des betreffenden Systems sehr wichtig. Die sozioökonomischen Eigenschaften haben auch einen Einfluss auf die Auswertung der dargestellten Faktoren.
Fazit: Die Analyse zeigt den Produzenten der RFID-Technologie, welche Erwartungen die Unternehmer haben und warum sie das RFID-System in Anspruch nehmen wollen. Je mehr Möglichkeiten das System besitzt desto mehr wünschenswert ist es. Die Anschaffungs- und die Einführungskosten des Systems sind auch ziemlich wichtig. Im Artikel wurde auch der Einfluss der betreffenden Eigenschaften (wie z. B. Unternehmensgröße, Art des Betriebs, usw.) auf die Einschätzung der ausgewählten Faktoren dargestellt. Die Ergebnisse bilden einen Beitrag zur Identifikation des Umfelds des Unternehmens, das die Entscheidungen im Bereich der neuen RFID-Technologien im konkreten Unternehmen zu beeinflussen vermag.

Codewörter: RFID-System, Unternehmen, Logistik, Lager, Transportsystem

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