

## Factors Influencing Investors' Decisions in Polish Companies as Demonstrated by RFID Systems

Marzena JANKOWSKA-MIHUŁOWICZ, Katarzyna CHUDY-LASKOWSKA

Rzeszow University of Technology, Rzeszów, Poland  
{mjanko,kacha877}@prz.edu.pl

**Abstract** The main objective of this paper is to identify, from a theoretical as well as empirical standpoint, factors preferred by managers when making investment decisions in the field of the RFID (Radio Frequency Identification) technology. Therefore, the paper is aimed at determining factors which are the most significant for decision makers in Polish enterprises. What can be inferred from the research is that key priorities indicated by Polish managers included: features of the new product, its attractiveness and quality along with implementation costs, price and return on investment (ROI). Managers with greater experience in implementing innovations and using RFID systems differed from inexperienced ones as they appreciated the advantages of the new product and represented a more optimistic investment approach. Managers with less experience in the implementation of innovation and RFID systems, despite perceiving the advantages of the system in question, were concerned with the cost and risk pertinent to investment decisions. During the research, the social survey method was used; applied the form survey examined 203 Polish managers. Were employed the Pearsons' Chi-Square and the Kruskal-Wallis ANOVA tests and relationships between qualitative and mixed characteristics were identified.

**Keywords:** Decision Making Factors, Investment Decisions, Radio Frequency Identification (RFID).

### 1 Introduction

This study discusses factors relevant for Polish managers in the decision-making process related to investing in an innovative RFID system. "Radio frequency identification (RFID) is a wireless, automatic authentication and data capturing technology [10]". Main components of RFID technology include an RFID transponder and an RFID reader, connected with a computer system. The development of RFID technology arouses interest among managers of businesses, mainly in industries such as: FMCG, transport, logistics, large retail establishments and medical industry. "In general, organizations implement RFID to enhance product visibility, [obtain] accurate and real time data, and sustainable competitive advantage [10]".

Findings reported in studies presented in this work are related to potential decisions to implement an innovative – and as yet commercially unavailable – RFID system with

an autonomous semi-passive RFID transponder. Such transponders constitute another stage in the evolution of automatic identification of objects. They may utilize various mechanisms such as obtaining energy from environment (e.g. from the electromagnetic field), and processing, storing and using it to perform additional functions (e.g. sensor functionality). This requires that batteries are replaced with another power source (e.g. a supercapacitor). Consequently, they are battery-free devices. An RFID transponder combines the strengths and eliminates weaknesses of a battery-powered semi-passive RFID transponder. Unique technical capabilities in automatic object identification, reliability and the lack of equivalent solutions dedicated to business render the new RFID transponder an innovative product [11]. If an investor implemented an RFID system with such transponders, he or she would be able to provide the customer with access to data on ambient conditions (e.g. humidity, temperature, pressure, light intensity and acceleration) to which a given commodity was subjected over a selected period of time. The results of such measurements would be stored in the RFID transponder's internal memory. Such information would be of benefit not only to the customer but also the owner of the RFID system (i.e. the investor). Documented resources on logistic, storage, transport, production and other processes at work in the organization will be used to further improve such processes.

The main purpose of the studies presented in this paper is to determine factors of greatest significance for Polish business owners when making investment decisions, with particular focus on RFID systems. The following research thesis was formulated: the hierarchy of factors significant for making investment decisions depends on Polish managers' experience in investing in RFID technologies.

## **2 Literature Review**

Publications enumerate key factors affecting decisions to invest in RFID in a company, including demand forecasts, determining product availability in stock, waste reduction, increase in sales, boosting supply chain effectiveness, as well as information transparency and accuracy [11]. Other studies isolate various factors which influence decisions related to investing in RFID such as: regulatory (e.g. security issues, environmental pressure, patent and copyright regulation), operational (e.g. accurate and real time information, product visibility, sustainable competitive advantage) and other (e.g. implementation cost, regulatory legislation, technological complexity, benefit trade-off) [10]. According to other research results "The technological factor is statistically significant across all regions, including North America, Europe and Asia. The organizational factor is significant only in developing countries like Southeast Asian countries and East Asian countries. Environmental factors like government intervention for facilitating RFID adoption are strong enough only in Southeast Asia and Europe [7]". In the case of medical organizations important factors of investment decision making (in RFID area) include "effectively managing and tracking medical equipment, monitoring and identifying patients, ensuring that the right medication is given to the right patient, and preventing the use of counterfeit medicine [9]". When making investment decisions it is crucial to take into account implementation steps such

as project scoping, analysis of the existing system, system design, prototype testing, implementation and continuous improvement. Moreover, some critical success factors: technological (selection of appropriate hardware and software, effective testing, sufficient technical support, clear process, data routine and clear performance measures), managerial (clear vision and good project management skills) and social (teamwork and effective communication) have also been identified [8].

The remaining part of the present work concerns investment decisions by Polish managers in collaboration with a team of researchers (from Department of Electronic and Telecommunications Systems, Faculty of Electrical and Computer Engineering, Rzeszów University of Technology), who developed an innovative RFID system with an autonomous semi-passive RFID transponder. The design and implementation of such system required the completion of many stages and making multiple closely related scientific, technical and managerial decisions, i.e.:

- analysis of requirements – practical assessment of implementation problems [2],
- designing system architecture, modelling – creating a mathematical model of the RFID system to automate the selected object identification process [5],
- design, programming, integration – defining mandatory system parameters and RFID devices for their reliable operation [1, 4],
- tests – preparing device demonstrators and experimentally verifying the operation of the RFID system being designed by means of such demonstrators [3, 6],
- prototyping and implementation – making RFID device prototypes intended for implementation in the company and participation in the commercialization phase,
- in the stages preceding, an assessment of conditions determining managers' decisions is necessary – i.e. market potential analysis, as well as studying the commercialization capability of the new product, an RFID system with an innovative RFID transponder [12].

In the above process, researchers are partnered by RFID system manufacturers (suppliers) and businesses implementing the RFID system (recipients). Each implementation of the RFID system in a company will constitute a separate, complex and risky process, necessitating cooperation between many stakeholders and many prospective decisions based on multiple criteria in significant risk conditions. Similar projects and studies are nowadays conducted worldwide; however, further in this paper we presented only the achievements of the team of scientists from Rzeszów.

### 3 Method

A social survey described in Table 1 was conducted for the purpose of the study.

**Table 1.** Research characteristics.

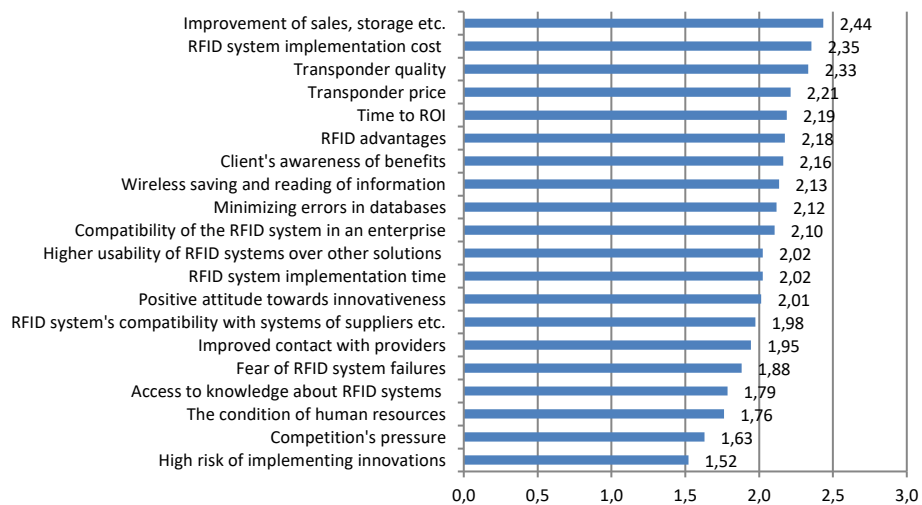
Research scope	Research description
Scope of research presented	Factors determining investment decisions in the field of RFID technology

Research tool	Questionnaire form
Research time frame	Four months – from 5 November 2014 to 5 February 2015
Population studied	Polish company managers from the top- and middle-management
Test sample selection criteria	Availability of respondents selected according to the type of business in which an RFID system with an autonomous semi-passive RFID transponder could potentially be used
Test sample size	A total of 203 managers' opinions were analysed
Types of businesses managed by subjects	According to criteria: sector (production – 34%, trade – 28% services – 28 %, and 14% – mixed business activities); scale of operations (47% – international, 15% – national, 18% – regional and 19% – local); legal and organizational form (47% – limited liability companies, 18% – joint-stock companies, 10% – general partnerships, 9% – registered partnerships and others); capital (59% – Polish and 41% – foreign)
Questionnaire form description	Questions (5 pages) concerning factors determining decision-making in the process of an RFID system implementation with an autonomous semi-passive RFID transponder; company information (1 page); an attachment (2 pages) containing an information sheet about automated object identification, autonomous semi-passive RFID transponder and typical applications of RFID systems
Research procedure description	500 colour copies of questionnaires were printed and handed over to managers all over Poland at trade fairs, scientific conferences and directly on company premises. Moreover, an electronic version of the questionnaire was made available for download on an Internet page and sent to managers via e-mail. The questionnaire was anonymous
Return of questionnaires	The managers filled in 203 questionnaires. 171 completed original questionnaires were returned (34% of all distributed); also, respondents filled in 32 questionnaires in an electronic form downloaded from the webpage containing research project description
Statistical analysis description	The following tests were employed: Pearsons' Chi-Square ( $\chi^2$ ) and the Kruskal-Wallis ANOVA. Relationships between qualitative and mixed characteristics were identified. The research was conducted with the help of Statistica 10. PL and Excel 10 software

The primary objective of the study was to determine factors most significant for managers of Polish companies in making investment decisions, with particular emphasis on an RFID system with an autonomous semi-passive RFID transponder. Detailed study objectives involved determining statistically significant differences (if any) between the significance of individual factors for managers with high and low experience in the matter, i.e. those who had implemented innovations and those had not; in addition – managers who had implemented an RFID system and those who had not implemented such a system.

## 4 Results

Twenty factors were selected in the study. Mean score indicating the significance of such factors for managers when making investment decisions on the implementation of an RFID system with an autonomous semi-passive RFID transponder in their company is shown in Figure 1.

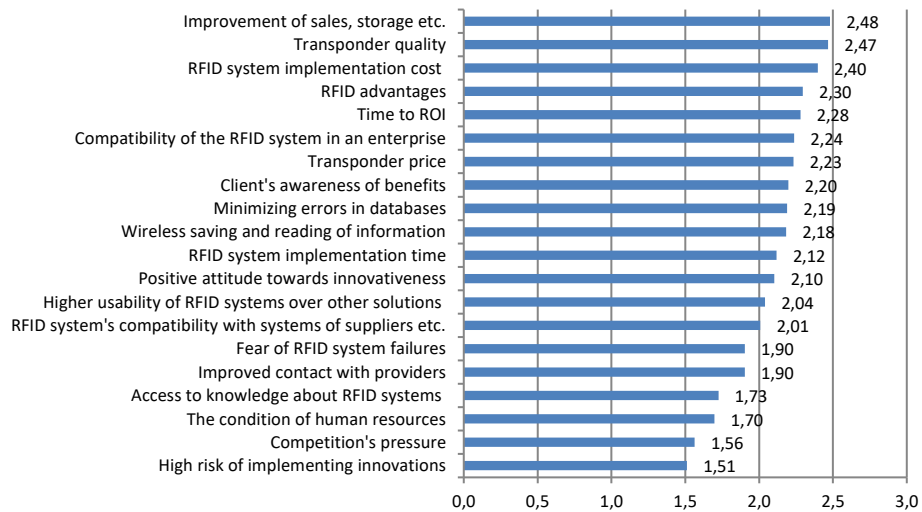


**Fig. 1.** Mean assessment of the significance of 20 selected factors for managers during the implementation of an RFID system in the company.

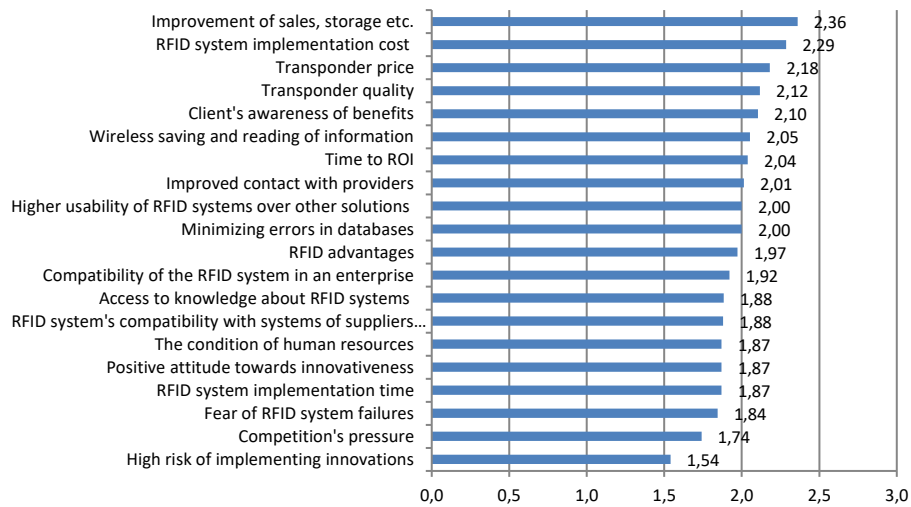
Highest potential impact on the decision to implement the RFID system in question by the subjects was exerted by three factors such as: various process improvements concerning e.g. sales, storage or transport (2.44), RFID system implementation cost (2.35) and transponder quality (2.33).

For managers who had already **implemented innovations** (Fig. 2) in their companies over the past 2 years, the most significant factors included: streamlined sales processes (2.48), transponder quality (2.47) and RFID system implementation cost (2.40).

Managers who **had not implemented innovations** (Fig. 3) also ranked streamlined sales processes the highest (2.36). As the second most significant factor they named RFID system implementation cost (2.29), with RFID transponder price as the third most significant factor (2.18).



**Fig. 2.** Scores awarded by managers who implemented innovations.



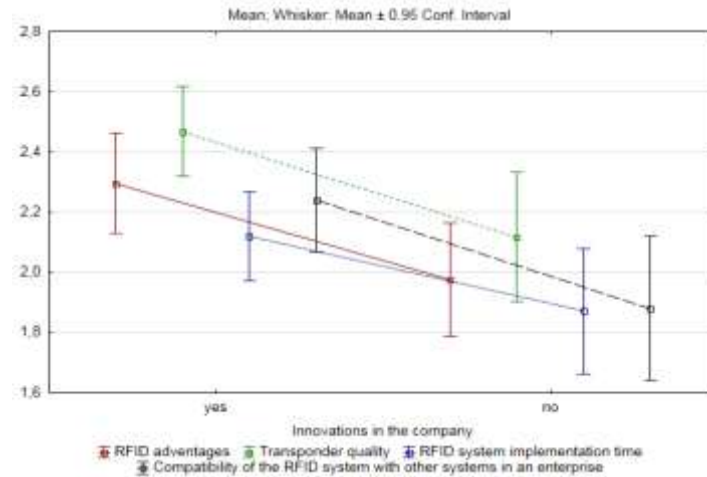
**Fig. 3.** Scores awarded by managers who did not implement innovations.

Tests were also carried out to identify differences in the assessment of the significance of individual factors both for managers of companies which had introduced innovations over the past two years and those which had not introduced innovations (Table 2).

**Table 2.** Factors divided according to businesses which implemented innovations and those which did not implement innovations – results of the Kruskal-Wallis ANOVA test.

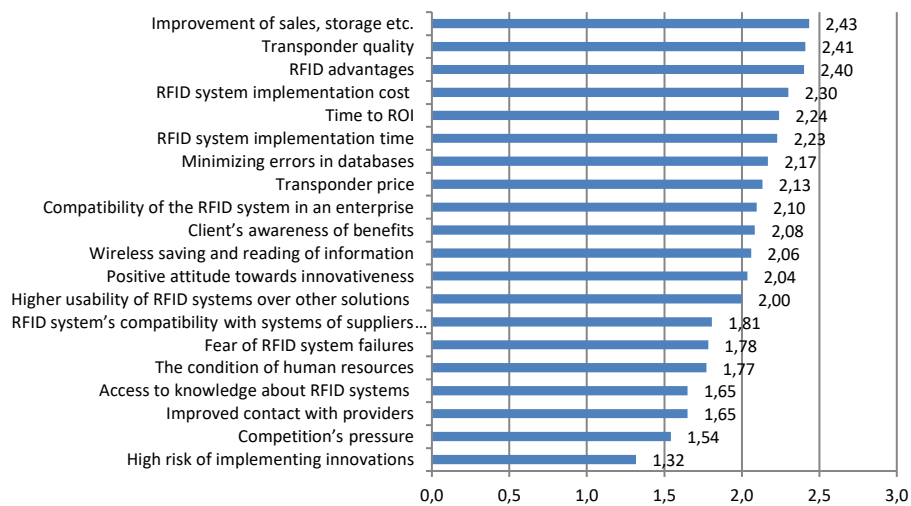
Factors of significance to managers when making investment decisions on the implementation of an RFID system with an autonomous semi-passive RFID transponder in their company	Innovation implementation		<i>p</i>
	No	Yes	
Wireless saving and reading of information	2.05	2.18	<i>0.366</i>
Advantages of the RFID system (e.g. automatic saving and reading of data, objects identification and real-time information flow, no batteries)	1.97	2.30	<i>0.014*</i>
Transponder price	2.18	2.23	<i>0.702</i>
Transponder quality	2.12	2.47	<i>0.006**</i>
RFID system implementation cost	2.29	2.40	<i>0.361</i>
RFID system implementation time	1.87	2.12	<i>0.049*</i>
Time to ROI in the RFID system	2.04	2.28	<i>0.067</i>
Competition's pressure	1.74	1.56	<i>0.228</i>
Positive attitude towards innovativeness and entrepreneurship	1.87	2.10	<i>0.055</i>
Improvement of sales, storage, transport, administrative and other processes	2.36	2.48	<i>0.340</i>
Client's awareness of benefits (improved service quality and satisfaction)	2.10	2.20	<i>0.496</i>
RFID system's compatibility with systems used by suppliers and	2.01	1.90	<i>0.440</i>
High risk of implementing innovations	1.54	1.51	<i>0.836</i>
Compatibility of the RFID system with other systems in an enterprise	1.88	2.24	<i>0.014*</i>
RFID system's compatibility with other systems used by suppliers and recipients	1.92	2.01	<i>0.582</i>
Fear of RFID system failures during the initial stage after implementation	1.84	1.90	<i>0.662</i>
Access to knowledge about RFID systems	1.88	1.73	<i>0.240</i>
Minimizing errors in databases by implementing the RFID	2.00	2.19	<i>0.162</i>
Higher usability of RFID systems over alternative solutions	2.00	2.04	<i>0.769</i>
The condition of human resources – its knowledge, qualifications, openness to change etc.	1.87	1.70	<i>0.175</i>

The analysis allows us to conclude that statistically significant difference in the assessment of the importance of analysed factors was present in the following cases: RFID system's advantages  $p < \alpha$  ( $p=0.014$ ), RFID transponder quality  $p < \alpha$  ( $p=0.006$ ), RFID system implementation time  $p < \alpha$  ( $p=0.041$ ) and RFID system's compatibility with other systems in the company  $p < \alpha$  ( $p=0.014$ ).



**Fig. 4.** Means interaction graph: innovations and the RFID system.

The means interaction graph (Fig. 4) shows that managers of companies in which innovations had repeatedly been introduced over the past two years gave higher scores than managers without such experience to: RFID system's advantages, RFID transponder quality, RFID system implementation time and RFID system's compatibility with other systems in the business.

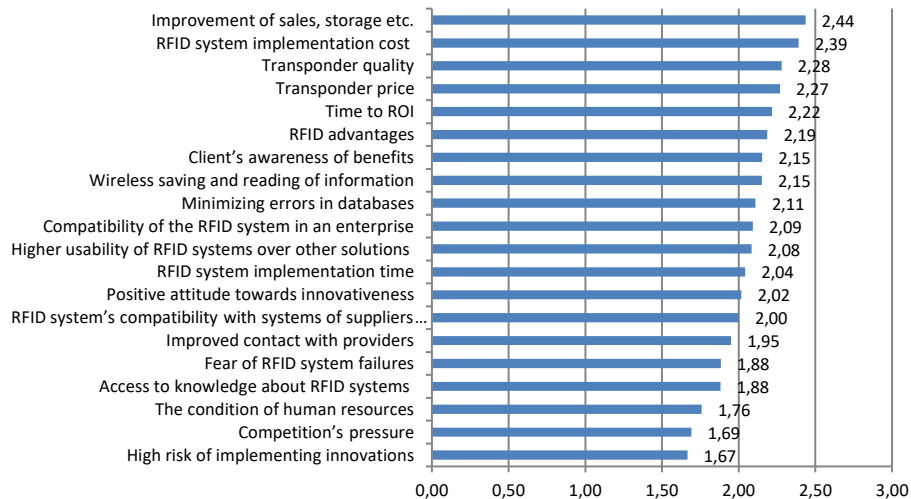


**Fig. 5.** Scores awarded by managers in businesses with RFID system(s).

It was also verified how the analysed factors were assessed by managers who already had some kind of RFID system in their company and those who did not have such a



system. Managers **in possession of RFID system(s)** (Fig. 5) awarded highest scores to: streamlined sales processes (2.43), transponder quality (2.41) and benefits of the RFID system (2.40). Managers in companies **without an RFID system** (Fig. 6) gave the highest scores to: process improvements (2.44), RFID system implementation cost (2.39) and RFID transponder quality (2.28).



**Fig. 6.** Scores awarded by managers in businesses without an RFID system.

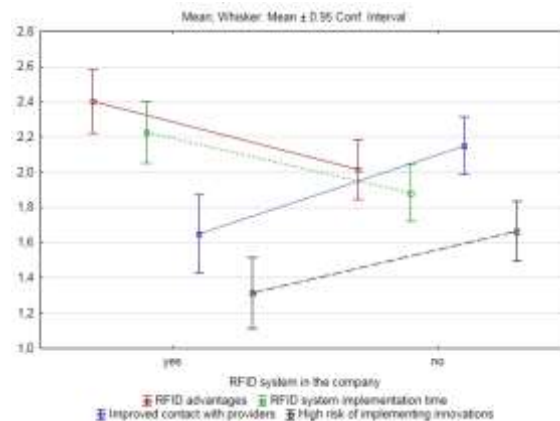
It was also verified (Tab. 3) whether the possession of any RFID system in the company influenced the assessment of the significance of individual factors.

**Table 3.** List of factors according to companies which had an RFID system and those which did not use any RFID system – results of Kruskal-Wallis ANOVA test.

Factors of significance to managers when making investment decisions on the implementation of an RFID system with an autonomous semi-passive RFID transponder in their company	RFID system implementation		<i>p</i>
	Yes	No	
Wireless saving and reading of information	2.06	2.19	0.369
RFID advantages (e.g. automatic saving and reading of data, objects identification and real-time information flow, no batteries)	2.40	2.02	0.003**
Transponder price	2.13	2.27	0.291
Transponder quality	2.41	2.28	0.312
RFID system implementation cost	2.30	2.39	0.451
RFID system implementation time	2.23	1.88	0.005**
Time to ROI in the RFID system	2.24	2.15	0.492
Competition's pressure	1.54	1.69	0.302
Positive attitude towards innovativeness and entrepreneurship	2.04	2.00	0.764
Improvement of sales, storage, transport, administrative and other processes	2.43	2.44	0.986

Factors of significance to managers when making investment decisions on the implementation of an RFID system with an autonomous semi-passive RFID transponder in their company (cont.)	RFID system implementation		<i>p</i>
	Yes	No	
Client's awareness of benefits (improved service quality and satisfaction)	2.08	2.22	0.334
Improved contact with providers	1.65	2.15	0***
High risk of implementing innovations	1.32	1.67	0.009**
Compatibility of the RFID system with other systems in an enterprise	2.10	2.11	0.924
RFID system's compatibility with systems used by suppliers and recipients	1.81	2.09	0.066
Fear of RFID system failures during the initial stage after implementation	1.78	1.95	0.218
Access to knowledge about RFID systems	1.65	1.88	0.080
Minimizing errors in databases by implementing the RFID system	2.17	2.08	0.529
Higher usability of RFID systems over alternative solutions	2.00	2.04	0.752
The condition of human resources – its knowledge, qualifications, openness to change etc.	1.77	1.76	0.918

Statistically significant differences were detected in four cases: RFID system's advantages  $p < \alpha$  ( $p=0.003$ ), RFID system implementation time  $p < \alpha$  ( $p=0.005$ ), streamlined contact with suppliers  $p < \alpha$  ( $p=0$ ) and high innovation implementation risk  $p < \alpha$  ( $p=0.009$ ).



**Fig. 7.** Means interaction graph concerning RFID system operation and its factors as well as innovation risk.

The means interaction graph (Fig. 7) shows that managers of companies which operated an RFID system ranked its advantages and implementation time higher. Managers whose companies did not have any RFID system attached greater importance to streamlined contact with suppliers and high risk of implementing innovations.

## 5 Conclusions

The purpose of this paper was to identify factors preferred by investors in the field of RFID technology. Accordingly, the following factors of **greatest importance to decision-makers in Polish businesses** were identified: various process improvements, RFID system implementation cost, transponder quality, RFID transponder price and time to ROI (similar results were obtained by: [7, 8, 9, 10, 11, 12]). It appears that managers' priorities include decision-making criteria related to product value, i.e. the attractiveness and quality of the product, and also to the cost of its implementation, its price and return on investment. In the survey, managers named the above factors as most important ones, with knowledge and risk ranked lower. For **experienced managers, who had implemented innovations in their businesses**, most significant factors included: streamlined sales processes, RFID transponder quality and RFID system implementation cost; for managers without such experience: streamlined sales processes, RFID system implementation cost and RFID transponder price. Statistically significant differences in the assessment of the analysed factors were present in four cases – experienced managers in companies which had introduced innovations awarded higher scores than managers without such experience to: RFID system's advantages, RFID transponder quality, RFID system implementation time and RFID system's compatibility with other systems in the business. The conclusion that could be drawn from the analysis of the above findings is that experienced managers, in contrast to inexperienced ones, pay more attention to product value than its implementation costs. The results may also suggest that managers who did not implement innovations in their company were limited by insufficient financial resources.

**Experienced managers who had implemented RFID system(s) in the company** assessed the following as the most significant: streamlined sales processes, transponder quality and RFID system's advantages; inexperienced ones most frequently indicated process improvements, RFID system implementation cost and RFID transponder quality. A statistically significant difference was found with respect to four factors – experienced managers ranked system advantages and system implementation time higher than inexperienced managers, with streamlined supplier contacts and risk of implementing innovations receiving lower scores than in the case of managers with less experience. Managers with considerable experience in operating RFID systems clearly appreciated many advantages of such systems and value of the new product (RFID transponder); in addition, RFID system implementation time, significant in gaining competitive advantage, was also an important factor for them. Managers without experience with an RFID system in their companies, in addition to the advantages of such system, emphasized factors such as cost, risk and relations with suppliers. Experience in the field of RFID technology clearly resulted in increased optimism in investment plans and priorities.

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“Synthesis of autonomous semi-passive transponder dedicated to operation in anticollision dynamic RFID systems”.

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