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CHALLENGES OF TAGGING GOODS IN SUPPLY CHAINS AND A CLOUD PERSPECTIVE WITH FOCUS ON SOME TRANSITIONAL ECONOMIES

ABSTRACT

This paper considers some of the barriers in implementing the RFID (radio frequency identification) technology for identifying, locating, tracking and tracing goods in supply chains, along with a model for adopting cloud services that can mitigate these obstacles in the transitional environment. The analysis is based on the assessments of the implementation impediments, given by the experts in the field of logistics: university professors, assistants and entrepreneurs from three Western Balkan countries (Montenegro, Serbia, and Bosnia and Herzegovina). Since the professionals' assessments are influenced by their experiences from the transitional economies, which are faced with limited abilities to invest in expensive business information systems, the main hypothesis is that moving the logistics into the cloud may resolve or at least alleviate the considered problems. On the basis of the available secondary literature resources on pros and cons of RFID implementation into supply chains, and the statistical analysis of the consciously completed questionnaires in the survey, the model for adopting cloud services for providing RFID-enabled goods and related activities in the considered economies is proposed at a logical level. The paper also gives some directions for further research work in this domain.

KEY WORDS

radio frequency identification (RFID); supply chain; transitional economy; model for adopting cloud;

1. INTRODUCTION

Radio frequency identification (RFID) is a prevailing technology that uses radio waves to identify, describe, localize, track and trace the products in supply chains. Each product in a supply chain has a tag affixed to it, which contains a unique identifier that can be used to identify a product by all supply chain participants [1]. Considering the great importance of supply chain integration, Huq et al. (2010) emphasized the importance of control over the flows of resources, goods and products [2]. In order to implement and constantly improve the efficiency of the control, it is necessary to receive reliable information in real time. The RFID provides such information as an automatic identification and data capturing system. Zhang et al. (2011) pointed out that the main aims of installing this system are higher security, reduced costs, improved quality and higher speed of logistics services, better identification of bottlenecks and operational disadvantages, as well as reducing the possibilities of loss or theft of cargo [3]. Yang et al. (2010) emphasized that the continuous tracking and tracing of cargo are of particular importance in the cases of high specific value shipments and increasing the overall efficiency of logistics management [4]. Besides barcode, GPS (Global Positioning System) and GSM (Global System for Mobile Communications), the main technology used for logistics tracking and tracing is the RFID. In supporting the importance of this technology, Musa et al. (2014) emphasized the RFID capabilities of identifying intra- and inter-enterprise location and visibility of resources, along with providing collaboration and integration through the whole supply chain network [5]. The great importance of visibility of goods in transport in terms of their monitoring and transparency in real time, since a decade and a half, was in focus of a number of authors [6, 7]. Later on, the importance of complete logistics information integration in the supply chain, which contributes to the efficient cooperation of all participants, has been highlighted [8, 9]. Current studies of RFID in supply chains are focused on inventory management, logistics and transport, assembly and manufacturing, asset tracking and object location, environment sensors [10, 11], etc. Also, by maturing RFID and cloud computing, using web based software to track and trace RFID-enabled objects around the world became the mainstream business tool [12].

Undoubtedly, the deployment of RFID technology is a challenging task in terms of costs, complexity, difficulties pertaining data management and maintenance, etc., especially for small and medium-size enterprises, as well as for those which function in the transitional economies (e.g. some Western Balkan countries). Accordingly, the rest of the paper is organized as follows: Section 2 gives an overview of some pros and cons of deploying RFID tagging and advanced back-end info-communication systems; Section 3 presents the outcomes of the survey conducted among the experts in logistics (i.e. among university professors, assistants, and entrepreneurs with university diplomas from Montenegro, Serbia, and Bosnia and Herzegovina) with the aim of stressing the key difficulties while introducing RFID technology into supply chains in the transitional environment; and, Section 4 proposes a model for adopting cloud services in such conditions in order to overcome or mitigate the existing impediments.

2. PROS AND CONS OF TAGGING GOODS IN SUPPLY CHAINS

The RFID technology has many advantages compared to bar code. It has a much higher capacity for the transmission of information. Also, it has the ability of parallel, simultaneous reading of multiple tags, and not exclusively in the line of sight. It can save additional information about the location, past events related to the products, information on the destination, quantity in stock, etc. This technology co-works at hybrid-platforms with wireless sensors that can monitor the conditions of perishable foods in transport, for instance, and trigger the actuators that automatically regulate the temperature and humidity inside refrigerators and/or frigo containers. In addition, RFID provides higher security, accuracy and efficiency; it speeds up the processes and reduces the cost of storage, handling and distribution. It has impact on improving sales at the expense of reducing the number of products disappeared in stocks [13]. Besides, Wamba et al. (2013) emphasized the importance of RFID for enabling interaction with other supply chain information systems, intra- and inter-organizational business transactions, creating the potential for business transformation in the supply chain and initiating transactions called “smart processes” [14]. They also highlighted the positive impact of RFID on reducing administration costs through re-engineering of the supply chain. Furthermore, RFID is today one of the pillars of the Internet of Things (IoT) paradigm, in addition to the networks of wireless sensors, middleware, cloud computing and IoT software. Also, it can be considered as one of the basic constituent elements of Cloud Internet of Things (CIoT) concept [15, 16], which is particularly interesting from the standpoint of further development of supply chain management, 3PL and 4PL services.

On the other side, Li et al. (2006) pointed out that the usage of RFID is debatable and controversial, due to three main reasons: “(1) technical standards are not final; (2) business benefits or return on investments are unclear; and (3) there is lack of industry-wide adoption” [13]. Even though this was stated ten years ago, these statements are still actual to a certain extent. Technical standards are improved, but standardization in this domain has not been completed, e.g., there are different types of RFID-WSN (wireless sensor network) integration architectures [17], but due to the best of our knowledge, there is no common RFID-WSN platform at the physical and transmission layers. Namely, RFID and WSNs have been conceived as different technologies, but they have to co-work along the supply chains (of perishable food, dangerous goods, etc.). There are also some barriers due to the lack of understanding the approaches to integrate the RFID technology into the existing IT/IS front- and back-end infrastructure. Another big problem is that RFID creates huge volumes of data (10-100 times the data of a bar code) that are difficult to manage with conventional computers [18]. Knowledge discovery in RFID-enabled goods, or in the sphere of the so-called RFID-cuboids, requires novel big data approaches and it is a new and underexplored field [19]. In addition, there are certain problems related to inventory inaccuracy, so-called bullwhip effects, and the needs for rethinking replenishment policies and techniques, etc. The scheme given in *Figure 1* summarizes some RFID pros and cons.

3. PILOT STUDY OF TAGGING GOODS IN SUPPLY CHAINS CHALLENGES IN THE TRANSITIONAL ECONOMIES

In addition to the above given short review in the field of (dis)advantages of implementing the RFID in supply chains, throughout the survey, we ranked and analysed some of the key challenges in adopting this technology in the transitional environment. It should be pointed out that we were faced with discontinuity in publishing review articles on RFID pros and cons in leading journals during the recent years. Namely, the reference [20] is the latest one of this kind, while some other, rather fragmental aspects of monitoring and controlling goods in supply chains have been recently considered [21, 22]. It seems that with the development of this technology and after its adaptation by

Disadvantages	Advantages
- Costs of tags and readers	- Non-line of sight scanning
- Costs of infrastructure	- Simultaneous multi-tag automatic reading
- Consulting and maintenance costs	- Time and labour reduction
- Engaging external experts	- Enhancing visibility and replenishment policies
- Lack of understanding	- Item level assets tracking
- Lack of personnel training	- Information rich
- Lack of some standards (RFID&WSN, e.g.)	- Knowledge discovery in RFID-cuboid
- Deployment difficulties	- Reliable and accurate
- Return-on-investments uncertainty	- Enhance security
- Sharing information with partners	- Robust
- (Down-stream) users security and privacy, etc.	- Co-work with sensors
	- Improved inventory management
	- Improved overall supply chain performances
	- Reduces losses and thefts
	- Possibility of using on-demand cloud services
	- Mitigating investment and operational costs, etc.

RFID-enabled goods

Figure 1 – Some (dis)advantages of implementing RFID into supply chains
Source: adapted from [18]

the biggest companies, this became a "cold" research field. However, this issue deserves to be put on the agenda again, particularly if we consider transitional economies, with the attempt to overcome or alleviate digital gaps. In this regard, we have realized a survey among experts in the field of logistics (university professors and assistants, as well as entrepreneurs with university degrees), selected from three countries of the Western Balkans (Montenegro, Serbia, and Bosnia and Herzegovina). We were trying to provide a larger number of respondents with appropriate competences and with a high level of logical thinking. Since we have the most professional and personal contacts in Montenegro, Serbia and Bosnia and Herzegovina that was a pragmatic motive to do our research over this sample. Besides, we have recently carried out a similar analysis over considerably smaller sample of respondents [23] from Montenegro, and we aim at broadening our observations over a larger number of consciously and knowingly answered polls. We succeeded, after several attempts, to collect approximately 50 answered polls from each of these countries, while the number of responders from academia was considerably greater in comparison to those from the field of industry and logistics. Besides, it is worth mentioning that we had previously done some analyses on the low level of institutional rationality in these three transitional economies, and concluded that it has a huge impact on the progressive transformations in these countries, including digital divide overcoming [24].

Survey analyses and their validity

The respondents (n=150) were firstly asked to rank the complexity of some crucial problems of implementing RFID technology in supply chains: C1-security and privacy, C2-technology issues, C3-costs, and C4-standardization. Each of these criteria is composed of a set of corresponding sub-criteria (*Table 1*). These dimensions are recognized in [20], i.e. in the latest review paper of such kind published in a highly rated journal, to the best of our knowledge. If we take into account the last stated, and the gap in adopting and exploiting the advanced info-communication systems in the considered countries, then it can serve as a justification of our choice.

Table 1 – Challenges in tagging goods in supply chains

C1-Security & Privacy (S&P)
C11-Securing data safety and customer privacy
C12-Ownership transfer issues between seller and buyer
C13-Undesired sharing tagged items information between seller and buyer
C2-Technology issues (T)
C21-Tag reading errors
C22-Tag localizing errors
C23-Need for engaging external experts
C24-Need for outsourcing
C3-Costs (C)
C31-High investments while introducing this technology
C32-Returns on investment vagueness
C33-Difficulties in estimating opportunity costs and risk of obsolescence
C4-Standardization (S)
C41-Developing standards for ensuring interoperability at the global level
C42-Alleviating regulatory aspects differences among countries

The ranking is made in such a way that to each group of criteria (C1-C4), listed in *Table 1*, the experts assigned the respective rank 1, 2, 3, or 4, in accordance to their subjective estimation based on the knowledge in the field, experiences, and intuition. Rank 1 belongs to the most serious set of barriers in

Table 2 – Final rank of the considered challenges

R/C	C1	C2	C3	C4
R1	4	2	1	3
R2	4	1	2	3
R3	3	4	1	2
R4	4	3	1	2
R5	4	2	1	3
...	...	...	...	...
R150	4	3	1	2
c_q	2.69299821	3.75939849	7.38916256	4.39882698
$\overline{w_q}$	0.14763932	0.20610301	0.40509902	0.24115865
$\overline{w_{qn}}$	0.14763932	0.206103	0.405099	0.241159
Rank	4	3	1	2

tagging supply chains, while rank 4 represents a set of the slightest problems.

The aggregate rank of the four selected criteria (C1-C4) over the respondents' estimations is determined by means of normalized average weight coefficients per criteria [24, 25, 26]. The idea of evaluating these weight coefficients is associated with the sum of ranks of each criterion, with respect to the assessments of the respondents (*Formula 1*):

$$c_q = \sum_{p=l}^{150} c_{qp}, q = \overline{1,4} \tag{1}$$

where, c_q- is the sum of ranks of each criterion, while q is the number of criteria (4), and p is the number of respondents (150); and, c_{qp} is rank of the q-th criteria estimated by the p-th respondent.

The average weight coefficient for each criterion is calculated by *Formula 2*:

$$\overline{w_q} = \left[\frac{c_q}{\sum_{q=1}^{4} c_q} \right]^{-1} \tag{2}$$

The normalized average weight coefficients are then calculated by *Formula 3*:

$$\overline{w_{qn}} = \frac{\overline{w_q}}{\sum_{q=1}^{4} \overline{w_q}} \tag{3}$$

The aggregate or final rank of analysed criteria (C1-C4) according to their severity, assessed by the 150 selected respondents (R1-R150), is processed by the equations (1)-(3), while the results are presented in *Table 2*. The criteria with the highest $\overline{w_{qn}}$, have the highest rank. This logic is applied to the rest of the analysed criteria. The calculus is realized in Excel by an Inter(R) Core™ i5 processor on 2.4 GHz (4GB RAM).

In addition, the experts were asked to assess the complexity of the problems associated with the sub-criteria within the main criteria sets (C1-C4), with one mark on a scale of 1 to 5, where 1 represents the lowest and 5 the highest rating problem in accordance to their perception, experiences and expertise in the domain. Then, the average score for each of the sub-criteria is calculated and the secondary level ranking of sub-problems or sub-criteria is made. The results are shown in *Table 3*. These calculations are realised in Excel, too.

Table 3 – Final rank of the considered key and sub-challenges

Rank 1	C3-Costs (C)
Sub rank 1	C31-High investments while introducing this technology (avg. 3.627)
Sub rank 2	C32-Returns on investment vagueness (avg. 3.440)
Sub rank 2	C33-Difficulties in estimating opportunity costs and risk of obsolescence (avg. 2.507)
Rank 2	C4-Standardization (S)
Sub rank 1	C41-Developing standards for ensuring interoperability at the global level (avg. 2.560)
Sub rank 2	C42-Alleviating regulatory aspects differences among countries (avg. 2.327)
Rank 3	C2-Technology issues (T)
Sub rank 1	C23-Need for engaging external experts (avg. 3.467)
Sub rank 2	C24-Need for outsourcing (avg. 2.307)
Sub rank 3	C21-Tag reading errors (avg. 1.573)
Sub rank 4:	C22-Tag localizing errors (avg. 1.500)
Rank 4:	C1-Security & Privacy (S&P)
Sub rank 1	C12-Ownership transfer issues between seller and buyer (avg. 3.627)
Sub rank 2	C13-Undesired sharing tagged items information between seller and buyer (avg. 3.440)
Sub rank 3	C11-Securing data safety and customer privacy (avg. 2.507)

In accordance to the obtained final rank, the costs of implementation are seen as the biggest problem in adopting RFID in supply chains. Then, the second position belongs to the standardization problems. These standards are still developing [27, 28], and we have to mention, once again, the lack of common RFID-WSN platform at physical and transmission layers, although there are several successful RFID-WSN applications of different kind. The third place is occupied by the technological issues like: needs for engaging external experts, outsourcing needs, tags reading and positioning errors, etc. The participants' security and privacy problems are rated as the lowest impediments. Albeit, it is to be pointed out that this problem should not be neglected; on the contrary. As the number of deployed RFID devices grows, the number of possible attacks grows at the same time as well. This is in collision with the intention of tagging goods on the level of each single item, and it deserves further investigations. After ranking the challenges in the prospective implementation of the RFID in supply chains in considered transitional economies, the Spearman's bi-variant correlation coefficients are calculated by *Formula 4* for each pair of the considered criteria sets. The Spearman's rank correlation coefficient (r_s) is a well-known, reliable and fairly simple method of testing both the strength and the direction (positive or negative) of any correlation between two variables [23]. It is calculated by *Formula 4*:

$$r_s = 1 - \left(\frac{6 \sum_{i=1}^{n} d_i^2}{n^3 - n} \right) \tag{4}$$

where, r_s is Spearman's rank correlation coefficient; d is the difference between two considered variables ranks; and n is the number of pairs of criteria compared by the respondents (i.e. 150 per each pair of considered criteria). In all the considered cases, Spearman's correlation coefficients, i.e.$\forall r_s > 0.99$, that means a strong positive correlation between the main sets of critical issues for employing RFID in supply chains in accordance to the experts' assessments (*Table 4*). These results have strong statistical significance ($\forall r_s^2 > 0.99$), too. The calculations are made like in the previous two cases in Excel. A sample of correlation coefficients calculus between pairs cost-technology issues (C,T) and technology issues-security & privacy (T,S&P) is given in *Table 5*. The correlation coefficients between other pairs of main criteria sets are calculated in the same way.

Also, we would like to examine in some more detail the correlation between groups of sub-criteria within the main criteria sets, e.g. between technology issues (T: C21, C22, C23, C24) on the one side, and costs (C: C31, C32, C33), standardization (S: C41, C42), and security and privacy (S&P: C11, C12, C13) on the other. These correlation coefficients are shown in *Table 6*, and they are obtained by the calculus in SPSS (ver. 16.0).

Within this context, we are particularly interested in: How the need for outsourcing (C24) correlates with other considered sub-criteria? - On the basis of the results given in *Table 6*, the following can be observed:

- There is a strong positive correlation (0.513) between concerns about the need for outsourcing (C24) and the ownership transfer issues between seller and buyer (C12). In the next section, it will be shown that outsourcing in a cloud is the most convenient model for adopting and implementing RFID-enabled goods in supply chains in the transitional economies. Therefore, this problem should be the problem of designers and providers of cloud services, but not of the users. However, it is good that the users are aware of this, since they should consider this issue in advance with potential providers of cloud services and regulate it through a contract;
- There is a medium positive correlation between the need for outsourcing (C24) and the standardization issues alleviating the regulatory aspect differences among countries (C42), and developing standards for ensuring interoperability at the global level (C41). These correlation coefficients are 0.369 and 0.357, respectively. As in the previous case, within the conditions of outsourcing in a cloud, standardization is a concern of the designers and providers of cloud services, more than of the users;
- There is a strong negative correlation between the need for outsourcing and the returns on investment vagueness (C32), along with the difficulties in estimating opportunity costs and the risk of obsolescence (C33). These coefficients are -0.830 and -0.548, respectively. It means that the need or the necessity of outsourcing in a cloud implies considerably less problems with these risks from the aspect of the users. These risks will be transferred, to a certain extent, from the user to the provider of cloud services.
- It might also be worth to point out the high correlation coefficients between:
- The need for engaging external experts (C23) and ownership transfer issues between seller and buyer (C12), which is 0.722. It is a question of confidence between the user and external expert(s) and it can be regulated through contact;
- Tag reading errors (C21) and concerns about standardization at the global level (C41) have a strong positive correlation (0.675). However, the problem of global standardization is currently on the road to be overcome by adopting the EPC Gen2 standard [27], and by implementing some white papers supported by China and EU countries [28]; if we abstract the absence of the unique RFID-WSN platform;

Table 4 – Correlation coefficients between pairs of analysed criteria

	(S) & (T)	(C) & (S&P)	(S) & (S&P)	(T) & (S&P)	(C) & (S)	(C) & (T)
Spearman coefficient [r_s]	0.999956331	0.999855006	0.999799349	0.999707975	0.999505805	0.999340057
Rank	1	2	3	4	5	6

Legend: (S) – standardization, (T) – technology, (C) – costs, (S&P) – security and privacy

Table 5 – A sample of calculating correlation coefficients between pairs (C,T) and (T,S&P)

No.	C	T	Rank (C)	Rank (T)	*d*	d^2	T	S&P	Rank (T)	Rank (S&P)	*d*	d^2
1	3.333	2.250	113	56	1.08	1.17	2.250	3.333	56	20	-1.08	1.17
2	3.667	2.000	55	82	1.67	2.78	2.000	3.000	82	91	-1.00	1.00
3	3.333	2.750	113	1	0.58	0.34	2.750	3.333	1	20	-0.58	0.34
4	3.667	1.750	55	121	1.92	3.67	1.750	3.000	121	91	-1.25	1.56
5	4.000	1.750	1	121	2.25	5.06	1.750	2.667	121	133	-0.92	0.84
6	4.000	2.000	1	82	2.00	4.00	2.000	3.333	82	20	-1.33	1.78
7	3.667	2.250	55	56	1.42	2.01	2.250	3.333	56	20	-1.08	1.17
8	4.000	2.250	1	22	1.50	2.25	2.250	3.000	22	91	-0.50	0.25
9	3.667	2.250	55	22	1.17	1.36	2.250	3.333	22	20	-0.83	0.69
10	3.333	2.750	113	1	0.58	0.34	2.750	3.333	1	20	-0.58	0.34
11	4.000	1.750	1	121	2.25	5.06	1.750	2.333	121	141	-0.58	0.34
12	3.667	2.000	55	82	1.67	2.78	2.000	3.667	82	6	-1.67	2.78
13	4.000	2.000	1	82	2.00	4.00	2.000	4.000	82	1	-2.00	4.00
14	3.333	2.500	113	22	0.83	0.69	2.500	3.667	22	6	-1.17	1.36
15	3.333	2.750	113	1	0.58	0.34	2.750	3.333	1	20	-0.58	0.34
16	3.667	1.750	55	121	1.92	3.67	1.750	3.000	121	91	-1.25	1.56
17	3.667	2.000	55	82	1.67	2.78	2.000	3.000	82	91	-1.00	1.00
18	4.000	1.750	1	121	2.25	5.06	1.750	2.333	121	141	-0.58	0.34
19	4.000	2.500	1	22	1.50	2.25	2.500	3.000	22	91	-0.50	0.25
20	3.333	2.500	113	56	1.08	1.17	2.500	3.333	56	20	-1.08	1.17
...	...	...	...	...	...	...	...	...	...	...	...	...
					$\sum d^2$	371.20					$\sum d^2$	164.26
r	0.999340057					*r*	0.999707975					
r^2	0.998680550					r^2	0.999416035					

Table 6 – Correlation between groups of variables (T vs. C, S, S&P)

T vs. C, S, S&P		C13	C32	C33	C41	C42	C11	C12	C13
Spearman's rho	C21 correl. coeff.	.142	-.221**	-.263**	.675**	-.031	.103	.588**	.232**
	Sig. (2-tailed)	.082	.007	.001	.000	.703	.209	.000	.004
	n	150	150	150	150	150	150	150	150
	C22 correl. coeff.	.110	-.110	-.244**	.134	-.100	-.763**	.358**	.597**
	Sig. (2-tailed)	.179	.179	.003	.101	.226	.000	.000	.000
	n	150	150	150	150	150	150	150	150
	C23 correl. coeff.	.142	-.337**	-.405**	.479**	.118	-.161*	.722**	.024
	Sig. (2-tailed)	.083	.000	.000	.000	.151	.050	.000	.768
	n	150	150	150	150	150	150	150	150
	C24 correl. coeff.	.005	-.830**	-.548**	.357**	.369**	.002	.513**	.271**
	Sig. (2-tailed)	.950	.000	.000	.000	.000	.981	.000	.001
	n	150	150	150	150	150	150	150	150

***Correlation is significant at the 0.01 level (2-tailed)*

– Tag localizing errors (C22) and securing data safety and customer privacy (C11) have a large negative correlation (-0.763). Statistically it has sense, but from the practical aspect it cannot be recommended as a way for providing customers' safety and privacy. The appropriate mechanisms of reducing tag localizing errors and uprising customers' safety and privacy are to be developed simultaneously.

The relations between other considered sub-criteria with high positive or negative correlation coefficients, with the appropriate level of statistical significance, can be interpreted by analogy.

4. CONCERNING CLOUD PERSPECTIVE IN ADOPTING RFID IN SUPPLY CHAINS

On the basis of the overview of the pros and cons of implementing RFID in supply chains and the statistical analysis of the survey conducted among the professionals from academia and the logistics sector in Montenegro, Serbia, and Bosnia and Herzegovina, in this section we would like to propose a model for adopting this advanced technology through the cloud. In that regard, firstly we shall give a short review of cloud models, including the methodological framework for assessing users' commitment to a certain type of sourcing in the cloud (4.1). Then, we shall propose, at the logical level, a model for adopting cloud in the developing countries which function in the transitional circumstances (4.2).

4.1 Blending cloud and RFID technology

Cloud computing is a model in which any and all resources: application software, processing power, data storage, backup facilities, development tools, etc., are delivered as a set of services via the Internet (or Intranet). Since cloud computing is relatively new and growing rapidly, the definitions and terminology are still in the state of flux [29, 30, 31]. Three basic models within the cloud concept are well-know and they are briefly described below:

– SaaS (software as a service): It is a delivery model for software in which the company, or other customers, pay for software on the pay-per-use basis instead of buying the software outright;
– PaaS (platform as a service): It is a delivery model for software identical to SaaS with the additional features, as the ability to customize data entry forms, screens, reports, and as the access to software development tools to change the way in which the software works;
– IaaS (interface as a service): It is a delivery model in which the customer acquires all the technology needs: storage hardware, network equipment, application software, operating system, data backup facilities, processing capabilities, etc.

The possibilities of using cloud today are huge, whether it comes to the public (based on the Internet), or private one (based on the Intranet). The public cloud, as its name suggests, comprises cloud services that exist in the Internet offered to anyone and any business. On the other hand, a private cloud is a cloud computing service established and hosted by an organization on its internal network and available only to employees and departments in that organization. Thus, a private cloud does not exist on the Internet, but rather within a specific organization of Intranet [29]. There are also possibilities of using community or hybrid cloud [32]. The relationships between partners in cloud (users, service operators, service designers, etc.) are regulated by SLA (Service Level Agreement). The SLA regulates the user's requirements and operator's obligations in terms of time, privacy, security, availability, reliability and determined procedures for data recovery. It specifies the price and method of penalty payment if the contract is breached for some reason, etc.

Figure 2 shows the costs of implementing RFID in supply chains and the main cloud concepts: SaaS, PaaS, and IaaS. This scheme can give an insight to the managers and stakeholders in the logistics sector of the considered countries into the relations between tagging goods in supply chains and cloud services. Direct costs of hardware should be replaced by IaaS costs; software ones by SaaS and/or PaaS, while cost of engaging external experts for the needs of system integration running and maintenance should be replaced by SaaS, PaaS and/or IaaS including their combinations when it is necessary, depending on the individual needs and preferences. The initial costs of deploying SaaS, PaaS, and/or IaaS are in any case considerably lower than the costs of buying this technology and its "in-house" setting, running and maintenance.

However, the question is: Which kind of sourcing in a cloud should be the most convenient in the case of the developing countries [33, 34, 35], like Montenegro, Serbia, and Bosnia and Herzegovina? - On the basis of the literature review of rather scarce available resources in the domain of outsourcing motives and decisions [36, 37, 38], it can be concluded that *outsourcing as a service* is the most suitable option for the considered transitional economies. On the second place might be placed *standardization of commodities* and *strategic partnership*, and on the third one – insourcing that seems presently unacceptable for the current needs of the analysed countries (*Figure 3*). These statements are explained in some more detail within the next paragraph.

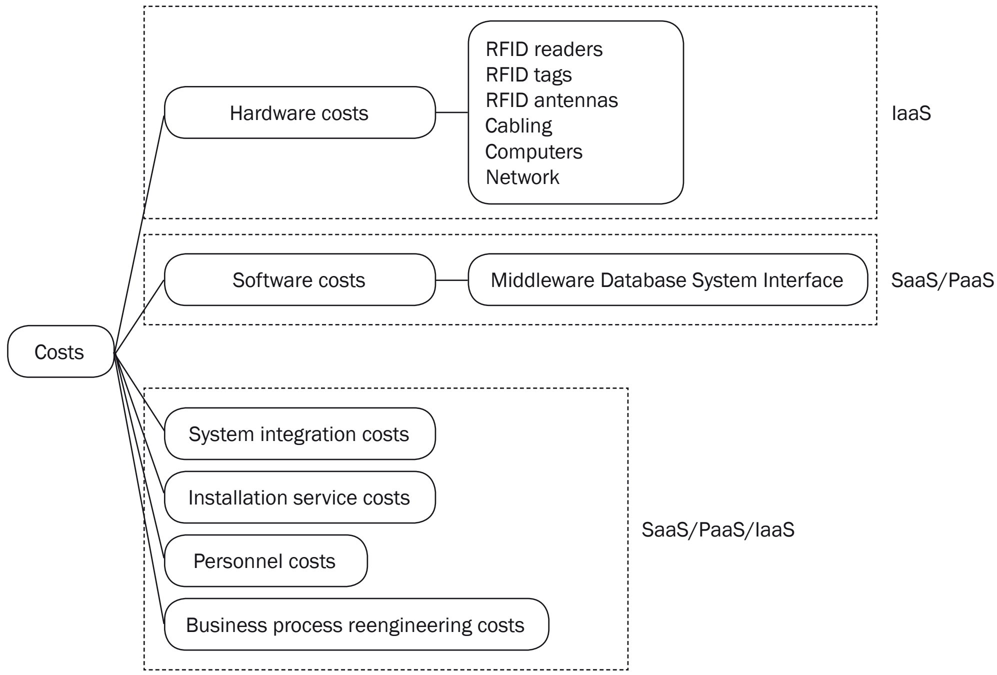

Figure 2 – RFID implementation costs tree and cloud modes
Source: adapted from [10, p. 91]

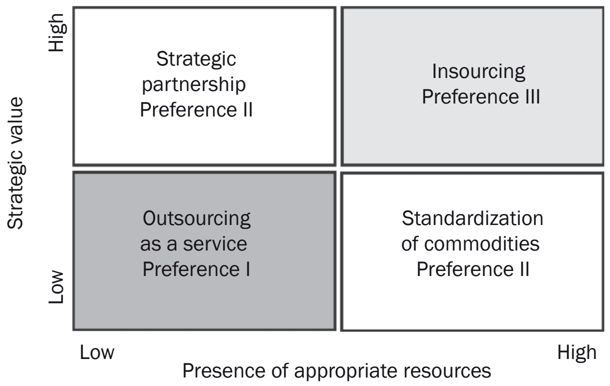

Figure 3 – The sourcing in a cloud motive framework for the transitional economies; Source: adapted from [38, p. 13]

Firstly, the models of “moving” logistics into cloud are briefly described as follows:

- Insourcing: It is the opposite of outsourcing. The activities of tagging and tracking goods in supply chains should be performed by the internal resources. Currently, insourcing seems inappropriate for the analysed countries, without the staff capacity and other resources increasing;
- Standardization of commodities: It means that IT/IS is not seen as a source that provides sustainable competitive advantages for the company. As consequence, the IT/IS can be freely shared with competitors without facing competitive disadvantage or losing the competitive advantage;
- Strategic partnership: It aims at gaining access to complementary resources and capabilities that are not present internally. However, the company retains the ownership and the control over the IT/IS that is linked to its strategic needs;
- Outsourcing: It implies that the rights are owned by the supplier during the delivery process as it owns the required resources for the IT/IS development. The responsibility for delivery is exclusively on the part of the external supplier. This model seems the simplest and the most acceptable in the case of the considered Western Balkan countries.

Afore described sourcing models are to be placed in the matrix of the logistics company’s strategic value, on the one side, and the presence of appropriate resources, on the other. The lower the strategic value of certain activity (i.e., RFID-enabling goods in supply chains) and the related expertise in the IT/IS development, the more the company is willing to outsource. When it comes to the presence of appropriate resources, the less the company’s resources own appropriate experiences, the more it will seek to overcome the knowledge gap by accessing external, complementary resources and capacities. As they have been operating since decades in the transitional environment, Montenegro, Serbia, and Bosnia and Herzegovina have low levels of strategic value when it comes to enhancing supply chains through tagging goods as well as other necessary resources in terms of human, organizational and physical capital. Therefore, *outsourcing in a cloud* should be taken as an optimal solution in the initial stage of adopting RFID technology for providing seamless goods’ stream and related activities.

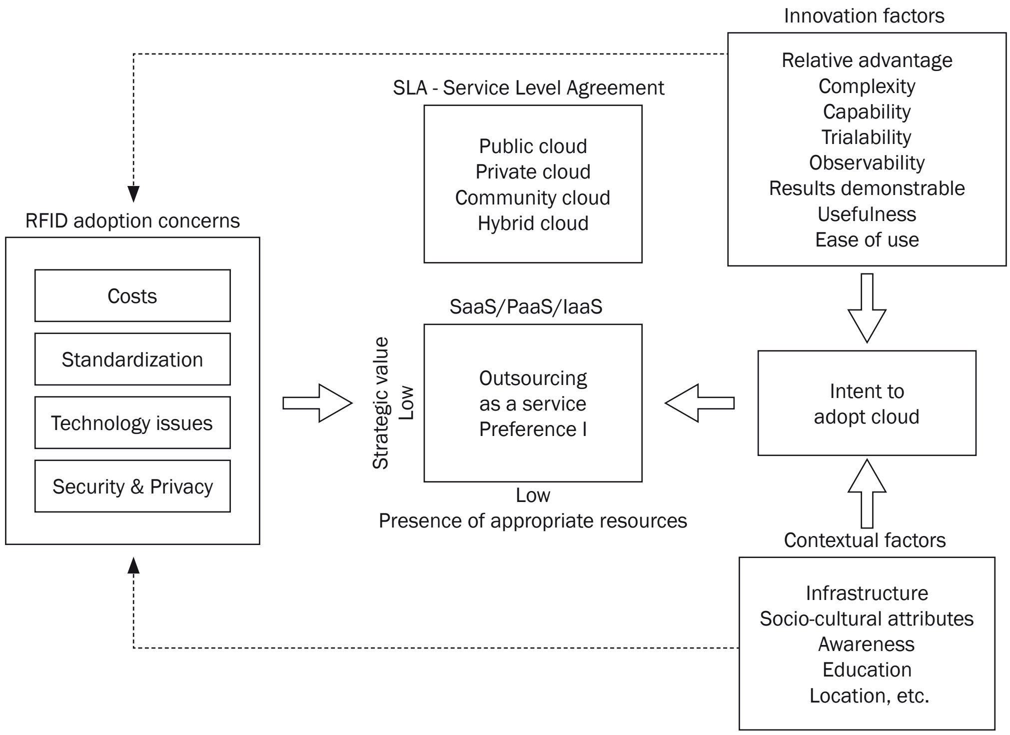

Figure 4 – A model of adopting RFID in supply chains

4.2 A model for adopting RFID

In accordance to the results of the statistical analysis given in Section 3 and on the basis of the previously given short review of sourcing models, a model has been proposed here for adopting outsourcing in a cloud, while deploying RFID in supply chains within the context of the transitional economies (*Figure 4*). As a reference for our model we also used a similar one developed by Humphery et al. (2016) and examined in [39].

In the centre of our model is outsourcing in a cloud as the most convenient sourcing model in the transitional conditions. This sourcing model can include SaaS, PaaS and/or IaaS services, within the frame of public, private, community, or hybrid cloud, while the relations between the users, providers and designers of the services are regulated by SLA (Service Level Agreement). The model is influenced by previously analysed barriers for implementing RFID into supply chains, while there is a strong negative correlation between the need for outsourcing on one side, and the risks of returns of investments vagueness and technology obsolesces, on the other, as shown in Section 3. Besides, the adoption of advanced RFID technology in supply chains should be motivated by the intent to adopt cloud. This intention is (in)directly influenced by the multidimensional nature of technology adoption and innovation diffusion (innovation factors) [40, 41]. However, innovation diffusion and adoption must take into consideration the existing economic and socio-cultural conditions of the adopter, i.e., the contextual factors. These innovation and contextual factors also affect indirectly the primary RFID adoption concerns (dashed lines in *Figure 4*). If these factors are on the lower level, their influence of the considered barriers in RFID adoption will be greater and vice versa.

By using positive deterministic paradigm, there is a positive correlation between innovation factors like: relative advantage (in comparison to the existing technologies), trialability, observability, demonstrable results, usefulness and ease of use, and the user's intent to adopt new technology. On the other hand, the complexity of new technology is negatively correlated to the intent of its adoption. The strength of these correlations should be examined at the level of each individual adoption case. When it comes to the contextual factors, one has to be aware that potential users do not have the same level of infrastructure at their disposal, e.g. access to the infrastructure (Internet) is not the same in urban and rural areas, etc. Socio-cultural attributes considerably vary from area to area, and their influence on the attempt to adopt RFID-tagging through outsourcing in a cloud should be examined also at the level of each particular case. The same is with the user's awareness about the need of adopting new technology, the level of their education, and their geographical location. According to some previous studies [39, 42], greater level of education implies greater readiness to adopt new technological solutions; albeit, there are still big differences in this respect among different geographical regions and within them.

The contextual and innovation variables and their mutual cross-correlations with the RFID adoption concerns and the core outsourcing model in a cloud should be examined due to the individual needs and preferences of the potential user(s) and this may be the subject of another research study. Apart from that, the information about the RFID technology impediments and cloud sourcing models opportunities, can serve as a key point in opening a discussion about the adoption of these advanced technologies. Enhancing such discussion, starting from the research community, was in fact our primary goal. Therefore, this pilot study can be used as an instrument for raising the awareness of the managers and stakeholders in the considered transitional economies about the necessity of the logistics innovation towards overcoming the existing technological gaps.

5. CONCLUSIONS

The paper gives an overview of pros and cons of adopting RFID technology in supply chains with a reference to the transitional economies in three Western Balkan countries (Montenegro, Serbia, and Bosnia and Herzegovina). Also, it proposes *outsourcing in a cloud* as a model which is theoretically most convenient for small and medium-size enterprises in the developing economies. On the basis of the results of the survey conducted among the experts in logistics in aforementioned countries, and the survey of the sourcing models in a cloud, the following can be concluded:

- Considered barriers in implementation of RFID into supply chains, have been ranked by the experts as follows: (1^{st}) costs, (2^{nd}) standardization, (3^{rd}) technological issues, and (4^{th}) security & privacy concerns;
- There is a strong positive bi-variant correlation, with the statistical significance, between each pair of the considered sets of criteria (barriers) in the survey (Spearman's coefficients: $\forall r_s>0.99$ and $\forall r_s^2>0.99$);
- There are strong negative cross-correlations between sub-criteria: the need for outsourcing, on the one side, and the returns on investment vagueness (-0.830) and the difficulties in estimating opportunity costs and risk of obsolescence (-0.548), on the other. This means that these risks can be overcome by outsourcing. It strongly supports our hypothesis that tagging goods in supply chains in the considered developing countries should be moved into the cloud;
- The methodological framework for adopting different sourcing models is applied to the analysed developing countries, and *outsourcing in a cloud* is proposed as the most suitable one, due to the scarcity of financial, technological and human resources in these countries;
- The advanced technology *adoption model* in developing countries is proposed at the logical level by taking into account the previously analysed barriers in implementing RFID in supply chains, along with some innovations and contextual factors. The *outsourcing in a cloud* is in the centre of this model, while the intent of its adoption is influenced by the users' individual needs and preferences including their economic and socio-cultural attributes.

Further research should include the in-depth interviews and discussions with managers and stakeholders in the transitional economies on this topic, beside the polls. Also, technology innovations and contextual factors that affect adopting cloud solutions should be assessed at the individual level(s). These analyses should also include comparing the objective initial costs of implementing the entire technology and cloud outsourcing model costs, on the concrete examples. The issues of stability and interoperability between the supply chain participants in both physical and cloud realms are to be taken into consideration as well.

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IZAZOVI PRAĆENJA ROBE U LANCIMA SNABDIJEVANJA I KLAUD PERSPEKTIVA SA OSVRTOM NA NEKE TRANZICIONE EKONOMIJE

APSTRAKT

U radu se analiziraju neke od ključnih barijera u implementaciji RFID (radio frequency identification, eng.) tehnologije za identifikaciju, lociranje i praćenje robe u lancima snabdijevanja, kao i model za prihvatanje klauda u cilju smanjenja ovih prepreka. Analiza je bazirana na subjektivnim procjenama eksperata u oblasti logistike: univerzitetskih profesora, asistenata i preduzetnika sa fakultetskom diplomom, iz tri države Zapadnog Balkana (Crne Gore, Srbije i Bosne i Hercegovone). Kako su procjene eksperata uslovljene njihovim iskustvima iz tranzicijskih ekonomija, koje imaju ograničene mogućnosti investiranja u skupe poslovne informacione sisteme, glavna hipoteza je da se izmiještanjem logističkog poslovanja u klaud mogu razriješiti, ili u najmanju ruku, ublažiti odnosni problemi. Na osnovu raspoloživih sekundarnih literaturnih izvora o prednostima i nedostacima implementacije RFID tehnologije u lancima snabdijevanja i statističkih analiza savjesno ispunjenih upitnika, predložen je na logičkom nivou, model za prihvatanje klaud usluga u obezbjeđivanju RFID-operabilnosti robe i pratećih aktivnosti u tranzicionom okruženju. Dodatno, u

radu su date i neke smjernice za dalja istraživanja u ovom domenu.

KLJUČNE RIJEČI

radio frekvencijska identifikacija (RFID); lanci snabdijevanja; tranziciona ekonomija; model za prihvatanje klauda;

REFERENCES

[1] Jamal K, Omer A, Qureshi S. Cloud computing solution and services for RFID based supply chain management. Advances in Internet of Things. 2013;3:79-85.

[2] Huq F, et al. An examination of the differential effects of transportation in supply chain optimization modeling. Operations and Logistics Management. 2010;21:269-286.

[3] Zhang G, et al. Research and application of steelmaking workplace crane logistics tracking system. Proceedings of the 2011 international conference on electronics and optoelectronics (ICEOE); 2011 July 29-31; Dalian, Lianing, China.

[4] Yang G-H, Xu K, Li V. Hybrid cargo-level tracking system for logistics. Proceedings of the IEEE 71st vehicular technology conference: VTC2010-Spring; 2010 May 16-19; Taipei, Taiwan.

[5] Musa A, Gunasekaran A, Yusuf Y. Supply chain product visibility: Methods, systems and impacts. Expert Systems with Applications. 2014;41:176-194.

[6] Christopher M. The agile supply chain: competing in volatile markets. Industrial Marketing Management. 2000;29(1):37-44.

[7] Kempainen K, Vepsäläinen APJ. Trends in industrial supply chains and networks. International Journal of Physical Distribution & Logistics Management. 2003;33(8):701-719.

[8] Fabbe-Costes N. Le role transformatif des SIC et TIC sur les interfaces multi-acteurs de la distribution et de la logistique. In: Fabbe-Costes N, Pache G, editors. Faire de la Recherche en Logistique et Distribution. Paris: Vuibert, 2000; p. 171-194. French

[9] How JL, Huang CH. Quantitative performance evaluation of RFID applications in the supply chain of the printing industry. Industrial Management and Data Systems. 2006;106(1):96-120.

[10] Sarac A, Absi N, Dauzere-Peres S. A literature review on the impact of RFID technologies on supply chain management. Int. J. Production Economics. 2010;128:77-95.

[11] Gaukler GM, Seifert RW. Item-level RFID in the retail supply chain. Production and Operations Management. 2007;16(1):65-76.

[12] Roberts D. Delivering RFID in the cloud. WAER blog [Internet]. 2013 July [cited 2016 April 29]. Available from: http://www.waersystems.com/blog/?p=31

[13] Li S. Radio frequency identification technology: Applications, technical challenges and strategies. Bryant University, Management Department Journal Articles. Paper 34; 2006. 26 p.

[14] Wamba SF, Anand A, Carter L. RFID applications, issues, methods and theory: A review of the AIS basket of top joumals. Procedia Technology. 2013;9:421-430.

[15] Borgia E. The Internet of Things vision: Key features, applications and open issues. Computer Communications. 2014;54:1-31.

[16] Owunwanne D, Goel R. Radio frequency identification (RFID) technology: Gaining a comparative value through cloud computing. Int. J. of Management & Information Systems. 2010;14(5):157-164.

[17] Mejjaouli S, Babiceanu RF. RFID-wireless sensor network integration: Decision models and optimization of logistics systems operations. Journal of Manufacturing Systems. 2015;35:234-245.

[18] Huber N, Michael K, McCathie L. Barriers to RFID adoption in the supply chain. Proceedings of the IEEE RFID Euroasia Conference; 2007 September 5-6; Istanbul, Turkey.

[19] Zhong RY, et al. A big data approach for logistics trajectory discovery from RFID-enabled product cuboids. Int. J. Production Economics. 2015;165:260-272.

[20] Kapoor G, Zhou W, Piramithu S. Challenges associated with RFID tag implementations in supply chains. European Journal of Information Systems. 2009;18:526-533.

[21] Oliveira RR, et al. An intelligent model for logistics management based on geofencing algorithm and RFID technology. Expert Systems with Applications. 2015;42:6082-6097.

[22] Verdouw CN, et al. Vizualization of food supply chains with the internet of things. Journal of Food Engineering. 2016;176:128-136.

[23] Draskovic M, Bauk S, Dzankic R. Concerning the increasing SCM integration with reference to some RFID challenges. Transformations in Business & Economics. 2016;15(1):77-93.

[24] Draskovic M, Bauk S, Delibasic M. Testing the level and factors of international rationality in Montenegro, Serbia and Bosnia and Herzegovina. Economics & Sociology. 2016;9(2):22-40.

[25] Vitic-Cetkovic A, Bauk S. E-services and positioning passenger ports in the context of cruise tourism promotion. Promet – Traffic & Transportation. 2014;26(1):83-93.

[26] Bauk S, Sekularac-Ivosevic S., Jolic N. Seaport positioning supported by the combination of some quantitative and qualitative approaches. Transport. 2015;30(4):385-396.

[27] GS1, Regulatory status for using RFID in the EPC Gen2 band (860 to 960 MHz) of the UHF spectrum. [Internet]. 2016 July [cited 2016 August 22]. Available from: http://www.gs1.org/docs/epc/UHF_Regulations.pdf [28] EU-China IoT Advisory Group, EU-China Join White Paper on Internet-of-Things Identification [Internet]. 2014 October [cited 2016 August 22]. Available from: http://www.miit.gov.cn/n1146312/n1146909/n1146991/n1648536/c3489529/part/3489530.pdf

[28] Haag S, Cummings M. Management Information Systems for the Information Age. New York: McGraw-Hill; 2013.

[29] Botta A, De Donato W, Persico V, Pescape A. Integration of Cloud computing and Internet of Things: A survey. Future Generation Computer Systems. 2016;56:684-700.

[30] Bayramustra M, Nasir V.A. A fad or feature of IT?: A comprehensive literature review on the cloud computing research. Int. J. of Information Management. 2016; 36: 635-644.

[31] Ristov P, Perić M, Tomas V. The implementation of cloud computing in shipping companies. Scientific Journal of Maritime Research. 2014;28:80-87.

[32] Avgerou C. Discourses on innovation and development in information systems in developing countries research. In: Galliers RD, Currie WL, editors. The Oxford Handbook of Management Information Systems – Critical Perspectives and New Directions. New York: United States by Oxford University Press Inc., 2011; p. 647-671.

[33] Roztocki N. Information technology success factors and models in developing and emerging economies. Information Technology for Development. 2011;17(3):163-167.

[34] Quereshi S. Globalization in development: do information and communication technology really matter? Information Technology for Development. 2011;17(4):249-252.

[35] Roy V, Aubert B. A Resource Based View of the Information Systems Sourcing Mode. Proceedings of the 33rd Hawaii International Conference on System Sciences; 2000 January 4-7; Maui, Hawaii.

[36] Johansson B, Muhic M. Explaining Sourcing Motives from Sourcing Decisions: The Sourcing Motive Framework. Procedia Technology. 2013;9:64-73.

[37] Muhic M. Sourcing motives behind sourcing decisions exposed through the Sourcing Decision Framework. International Journal of Information Systems and Project Management. 2013;2(1):5-17.

[38] Humphrey MS et al. Conceptualizing a model for adopting cloud computing in education. Int. J. of information Management. 2016;36:183-191.

[39] Rofers EM. Diffusion of innovation (5th Edition). New York, NY: The Free Press; 2003.

[40] Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly. 1989;13(3):319-339.

[41] Cruz-Jesus F, et al. The education-related digital divide: An analysis for the EU-28. Computers in Human Behavior. 2016;56:72-82.