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APPLYING RFID TECHNOLOGY IN THE RETAIL INDUSTRY – BENEFITS AND CONCERNS FROM THE CONSUMER'S PERSPECTIVE

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Abstract

This paper discusses the benefits and costs of RFID (Radio Frequency Identification) technology in the retail sector. RFID is an enabling technology for the Internet of Things (IoT) concept, which constitutes a new vision of the Internet as a medium and forum that expands into our everyday lives and connects us virtually to all of the objects that surround us. This paper gives a balanced view of RFID in retailing by showing its current and potential benefits and costs, in particular from the consumer's perspective. The authors also present the findings of a survey that examined the attitudes of Hungarian consumers towards the potential threats of RFID, and conclude that these attitudes are part of a larger psychological construct, which embraces opinions and attitudes towards new information and communications technologies in general. Significant relationships between consumer demography and attitudes towards RFID applications were also revealed. The paper suggests a solution to the privacy problem of current RFID applications, which has been elaborated by researchers of the IoT Research Institute at the Eszterházy Károly College in Hungary: if RFID technology were integrated with NFC-enabled mobile phones that included a user interface, consumers would be able to gain control over radio frequency communication.

Keywords: Internet of Things (IoT), RFID, retail sector, customer value, consumer privacy

JEL Classification: O33, M31

Introduction

A central criticism of the Internet of Things (IoT) paradigm is that it may infringe on the privacy of consumers and bring about a "surveillance society". According to the prevailing vision of IoT today, most of the objects around us will be provided with unique identifiers that will transfer information over a computer network for analysis. In the centre of this

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new technology are the so-called RFID (Radio Frequency IDentification) tags, which can be placed on products and even on living things and are able to communicate with a computer, for example, providing data about the location and properties of a particular tag at a given time. Through RFID, it would be possible for computers to identify any object in the world and gather information about it. The data collected is important not only for existing business models. It can also open the way for a plethora of innovative applications in various sectors of the economy and also in everyday life. In addition to RFID, the future Internet will be integrated with an array of similar technologies – such as Bluetooth, Near Field Communication (NFC), Wi-Fi, GPS, etc. – to create “pervasive” or “ubiquitous” computing (Weiser, 1991) that will have a strong influence on how we live and do business (Stanford, 2003).

The term of IoT was invented by Kevin Ashton (1999) who pioneered RFID in the field of supply chain management. Ashton became interested in the technology when he worked for Procter & Gamble, and he later founded a research consortium at the Massachusetts Institute of Technology (MIT) with the aim of establishing a global open standard for RFID applications. The consortium, called the Auto-ID Centre (today: Auto-ID Labs and EPC global), was an industry sponsored research project, which licensed the new technology to GS1, an international non-profit organisation that develops and maintains supply and demand chain standards. Founded in 1999, the Auto-ID Centre was a partnership of almost 100 global companies and seven leading research universities: MIT, University of Cambridge, University of Adelaide, Keio University, University of St. Gallen, Fudan University and KAIST (Auto ID-Lab, 2014). Since then, RFID has – rather suddenly – become an important social issue, as some companies have started applying the technology beyond their manufacturing plants and supply chain operations, and have even reached consumers' homes via retailers.

In this paper we discuss the benefits and costs of RFID applications in retailing, in particular from the consumer's perspective. Our research questions are as follows: What are the main benefits and costs of RFID solutions in retailing to the consumer? What are the attitudes of consumers towards the technology? Do they have RFID-specific fears and perceptions, or are their attitudes towards RFID part of a more universal attitude towards information society and relating technologies? The methods used are literature review, consumer survey and case study. As for the case study, at the end of the paper we present a technological innovation developed by researchers at the Eszterházy Károly College (EKC) in Hungary, who try to prove that there is a direction in IoT research that will not lead to the pitfalls identified in current literature. The enhanced technology would facilitate the spread of RFID in the retail industry by allowing consumers to control the invisible information flow between their products and other parties.

1. Literature review – the benefits and costs of RFID solutions in retailing

The Electronic Product Code (EPC) Network is an open technology infrastructure that allows computers to identify and track objects automatically. EPCs are typically encoded on RFID tags and thus give a unique identity to tagged objects. EPC was officially launched in 2003 in a Chicago-based Symposium, which was supported by nearly 100 major food, consumer goods, retailing, transportation and pharmaceutical companies from around the world. The participants agreed that RFID will become a fundamental enabling

technology for economic growth in the next 50 years (Santucci, 2010). Supporting the industrial and social impact of the Symposium, Wal-Mart obligated its biggest suppliers to adapt RFID tags on shipped items at the pallet level (Bansal, 2003).

In order to discuss the marketing potential of RFID, we have to understand how the technology works in practice. To put it simply, an RFID tag is a microchip attached to a small radio antenna. It is a tiny wireless computer, a “next generation bar-code”. Using radio waves, information can be sent between the tag (transponder), which is embedded on a product, and a device called the reader (interrogator). The reader is a processing unit connected to a radio antenna and a computer. The interrogator can read and/or write data to the RFID tag from a distance. Readers can be fixed to static objects (e.g. to warehouse doors) or mobile (e.g. integrated into a portable computer). Tags have varying performance and complexity (SEUC, 2003): “Passive” tags can be small like a grain of rice, because they have small memory and no battery of their own. They are the most common and the cheapest to produce. Passive tags are “awakened” by the energy field transmitted by the reader; this energy field provides power for the tag to respond to the reader. In contrast, “active” tags have their own batteries and larger memories, and they are physically larger. Originally, only active tags could initiate communication with the reader (“broadcasting”). The read distance of Gen2 passive UHF (Ultra High Frequency) RFID tags is between 1–15 meters today (SkyRFID, 2014). Active tags can transmit their signals over a longer distance than passive ones.

Although the revenue generated by RFID technology today is quite low in comparison with other information and communications technologies (ICT), such as mobile phones (€ 600 billion), forecasts promise an above-average growth for the sector: from €3.5 billion in 2009 to €15.5 billion in 2016 (RACE, 2010). Several sectors of the economy can realize the benefits of RFID (Gubbi et al., 2013), including national defence, transportation, housing, public service, environment and business. For example, tags can be used instead of toll tickets (Swedberg, 2004), or for instance to track bags in airport transport systems (Mishra and Mishra, 2010), eliminate lost books and speed up checkout in libraries (Molnar and Wagner, 2004), help manage inmates in prisons (Hickman et al., 2010) and even prevent terrorists from sneaking weapons into cargo containers (Juels, 2006).

The technology will probably attract the interests of researchers from the fields of marketing and supply chain management first (Angeles, 2005). The firm-level financial benefits of RFID primarily stem from the growing productivity of manufacturing, warehousing and retailing, as well as better customer experience (Pisello, 2006). The potentials created by the use of passive tags have given rise to many applications in supply chain management (Bacheldorand Sullivan, 2004): they decrease inventory management costs associated with scanning items, out-of-stock (OOS) items, item theft and counterfeiting. Tags can be used in inbound and outbound logistics to verify the contents of shipment and to identify and track vehicles, raw materials and other expensive portable equipment. Products can be tracked along the whole supply chain; in the case of food products, for example, RFID is used to detect potential spoilage conditions and ensure food safety.

To persuade business owners to adopt RFID, it is important to calculate the pay-off time and return on investment (ROI) of RFID systems. According to experts, the technology can generate an extra 2–7 percent increase in revenue, with a 2–5 percent reduction in operating expenses, and thus result in a 200 percent ROI for a typical manufacturing, warehousing and retailing firm (Pisello, 2006). Recent surveys have also justified the benefits of RFID in

retailing (ChainLink Research, 2014). Around the turn of the new millennium, large and innovative retailers implemented pallet level tagging in their upstream supply chains. Today, an increasing number of retailers started to realize the operational and financial benefits, primarily through increased consumer satisfaction due to item-level tagging, which also led to the one-billion tagged items milestone and further decreases in the costs of the technology. In the following, we deal with the effects of RFID on customer value by discussing the potential benefits and costs of the technology in the retail sector.

2. Benefits of RFID

Customer value is a fundamental marketing concept that is a combination of quality, service, and price (Kotler and Keller, 2012). We can also define customer value as the difference between the benefits (e.g. product, services, personnel, image) the customer gains from owning and using a product and the costs of obtaining and using the product (e.g. monetary, time, energy, psychological). Retailers can add value to consumer purchases through better services, for which RFID provides several opportunities. Basically, it can increase customer value through more accurate tracking of items from the manufacturer to the store shelf, and even after the moment of purchase. Other potential advantages to the customer include the following (Viola, 2008; Motorola, 2012; ChainLink Research, 2014):

- Better purchasing experience;
- Increased product safety, fewer counterfeit items, and faster product recalls;
- Less empty space on shelves, fewer misplaced goods, and less employee theft, which all result in greater product selection and availability;
- Lower prices mainly due to decreased supply chain costs;
- More convenient and faster checkout;
- More opportunity for consumer behaviour research and more accurate targeting (e.g. more individualized offers and promotions);
- Real-time and more enhanced information about products;
- Reduced labour requirements for backroom functions and thus more staff available for consumers;
- “Seamless” omni-channel shopping experience.

In spite of the many opportunities offered by RFID to increase consumer value, studies have put more focus on considerations pertinent more directly to manufacturers and retailers (Jensen, Cazier and Dave, 2008). Some fancy RFID applications, such as smart mirrors, smart fitting rooms (Swedberg, 2007), and smart shopping carts can directly improve consumer experience. However, these uses are not the most important reasons for adopting the technology. In a worldwide survey, retailers reported better inventory accuracy, reduced OOS and better on-floor availability as the main reasons for implementing RFID (ChainLink Research, 2014). More efficient management of stock and store shelves reduces not only labour costs, but also customer walk-outs and customer loss. The average OOS ratio in the world is 8.3 percent, the majority (70–75%) of which is directly caused by poor retail store practices including ordering, forecasting, shelving and

replenishing. When encountering an OOS situation, 21–43 percent of consumers make the purchase in another shop, while 7–25 percent do not buy the product at all. OOS on average results in a 4 percent loss of sales (Gruen, Corsten and Bharadwaj, 2002) and costs the large stone-hundred retailers an estimated \$69 billion a year (Motorola, 2012).

RFID can play an important role in changing current retail models. According to RSR Research, in order to meet the “anytime-anywhere” customer expectations, 53 percent of retailers aim at to introduce omni-channel fulfilment to allow customers to purchase, take delivery of and return a product through the channel of their choice (Baird and Kilcourse, 2014). Furthermore, nine out of ten retailers regard system-wide inventory visibility as the most valuable advantage to be gained by adopting omni-channel strategy. Still, only 37 percent have implemented company-wide inventory visibility solutions, which offers promising growth opportunities for RFID applications.

Once retailers adopt RFID, they may discover other profitable ways of using the technology, including the prevention of product theft and various supply chain applications such as receipt verification, inventory counting, picking and packing, etc. For example, a cycle count which takes several days manually can be taken in a matter of minutes using RFID. Retailers who have adopted the technology have also noted a reduction in data-entry errors caused by sales staff or damaged tags and a reduction in labour force required for scanning and inspection of items (ChainLink Research, 2014). Most of these advantages indirectly contribute to higher customer value.

An interesting and also disquieting potential of RFID is the use of tags on durable goods and apparel used or worn by consumers (Fusaro, 2004). The benefits of tagging clothes for consumers could be realized, for instance, if washing machines had RFID readers and could choose the appropriate washing cycle with the help of the tags and even warn consumers about incompatible garments (Want, 2006). Similarly, microwave ovens could read the tags attached to frozen meals and automatically adjust the time and method for cooking the food properly. In the case of durable goods, tags could provide information after the purchase about warranty status, point-of-sale (POS) or last maintenance date.

As for the technical part, tags can be embedded on items and loyalty cards, while readers can be applied at checkouts. Shopping carts can also be mounted with tags and even with readers. Tagged shopping carts can collect in-store location data on shopper behaviour and make the planning of POS displays and shelf layout easier (Swedberg, 2013). Equipping carts with RFID readers (“smart cart”) can speed up the process of shopping, billing, and payment, as the cart reads the tag attached to the article being put in it and forwards the information to a database (Kumar, Gopalakrishna and Ramesha, 2013). Tags placed on loyalty cards can help retailers monitor customers’ purchasing behaviour and demographic characteristics (Swedberg, 2009) and help the retailer better tailor its market offerings.

3. Costs of RFID

Costs of RFID investments should be examined from the perspectives of both the retailer and the consumer. Regarding the former, the price of tags is becoming of a matter of little importance due to developments in manufacturing technology (Frost & Sullivan, 2004). Economy of scale effects also contribute to falling production costs. In fact, the price of a passive tag decreased by more than 80 percent between 2003 and 2010, from 60 euro cents

to less than 10 cents (RACE, 2010). Still, retailers in the short run may find it reasonable to tag products only at the pallet level, or tag high-margin products. Other costs include that of hardware (e.g. reader) and software, the integration of RFID with other elements of the marketing information system (Reynolds and Lynch, 2004), and the optimization of the number of readers and the placement of readers to create an effective communication environment (Engels, 2001; Pering, Ballagasand Want, 2005; all cited in Curtin, Kauffman and Riggins, 2007).

When introducing new technologies, factors affecting adoption as well as long term, social costs have to be taken into consideration too. Consumer value in general is reduced by the monetary, time, energy and psychological costs of obtaining and using a product. As shown earlier, RFID can help retailers reduce price, as well as the time and energy consumers need to obtain a product. On the other hand, psychological costs can be high for some consumers and in certain buying situations. The social concerns of an increasing volume of RFID applications can be discussed from various perspectives, including ethics, health and legislation. Several authors (e.g. Stajano, 2005; Curtin, Kauffman and Riggins, 2007; Slette-meås, 2009) and NGOs have drawn attention to the dangers of RFID, and especially to the infringement of privacy rights, which can give rise to an “Orwellian surveillance society”. Regarding short-term economic considerations, the fear of unanticipated tracing of products can discourage consumers from buying them. A relevant example is the 2003 protest against Gillette, because the company inserted RFID tags into men’s shaver packages (Boycott Gillette, 2003). Other privacy issues relate to the covert reading of tags and consumer profiling, though at the moment only messages exchanged between readers and tags can be kept under surveillance. The likelihood of tracking and information leaks increases with the amount of readers searching for tags outside the store, the number of activated tags passed over to consumers, and the number of “attackers” breaking into communication networks and spying on consumers (Spiekermann, 2012).

The inherent problem of RFID is that communication through electromagnetic waves is invisible for humans and tags can be hidden, so consumers do not know if communication is occurring or when it is occurring. Some may fear that implanted tags will be required for people one day, the same way they are required for household pets in some countries today. Nursing homes and assisted-living facilities are already using RFID to monitor the whereabouts of residents (O’Connor, 2009). Placing tags on employees and equipment may also be regarded as excessive supervision by employees and worker unions, and may cause problems in spreading the new technology along the supply chain (Gilbert, 2003). RFID-related services offered post-purchase may also cause concerns. Consumers may be anxious about the possibility of their homes being scanned from outside to see what goods they possess. Although tags can be read only from a limited distance, development in this field will increase the feeling of insecurity among consumers and raise legal questions.

The EU has also expressed its concerns about its citizens’ privacy regarding RFID technology. To supplement the European Directive on Data Protection (Directive 95/46/EC), the Commission issued a Recommendation on “RFID Privacy, Data Protection and Security” in May 2009. The Recommendation provides guidelines on how to process data within RFID systems and how to evaluate privacy and data protection issues of RFID applications through so-called Privacy Impact Assessments (PIA). The revised Directive had to be transferred into national laws by May 2011. The PIA Framework has been designed to uncover the privacy risks associated with RFID applications: it helps

organizations determine whether their application is following the data protection guidelines set by the EU (RFID in Europe, 2012). The PIA Framework contains the following recommendation:

“Retailers should deactivate or remove at the point of sale tags used in their application, unless consumers, after being informed of the policy in accordance with this Framework, give their consent to keep tags operational. Retailers are not required to deactivate or remove tags if the PIA report concludes that tags that are used in a retail application and would remain operational after the point of sale do not represent a likely threat to privacy or the protection of personal data as stated in point 12 of the same Recommendation. Deactivation of the tags should be understood as any process that stops those interactions of a tag with its environment which do not require the active involvement of the consumer”. (European Commission, 2011, p. 9)

PIA is a promising initiative for several reasons (Spiekermann, 2012): it aims to treat a problem in a holistic way, it has been worked out by industry actors through stakeholder conciliation, it is an international effort (it was heavily influenced by US industry policy makers), and it can be flexibly adapted to various industries. Furthermore, consumers expect their governments to regulate the development of RFID directly, in particular in the fields of consumer privacy and security (Jensen, Cazier and Dave, 2008). A major question is how committed firms will be to comply with PIA recommendations and whether there will be any sanctions (and what kind) if they do not –especially because consumers in general do not trust retailers to comply with the European data protection directives (Roussos, 2006).

Research on the relationship between consumer psychology and RFID applications is relatively scant and kicked off only in 2002, primarily in technically oriented journals, but little attention has been paid to consumer relevant issues (Ngai et al., 2008). A survey of 1,000 U.S. citizens (Collins, 2004) showed that consumers’ main apprehensions regarding the technology are the use of consumer data by a third party, an increase in targeted direct marketing, and the potential for tracking consumers through their product purchases. The most-valued advantages of the technology from a consumer perspective were its potential for faster recovery of lost items, improved car anti-theft capabilities, and the savings stemming from reduced product costs. European consumers have somewhat more favourable perceptions of the technology (Cappemini, 2005). Consumer acceptance of new technologies depends on several factors, including readiness to try, the influence of others, the characteristics of the innovation (e.g. relative advantage, compatibility with consumers’ values, communicability), and organizations’ readiness to adopt the innovation (Kotler and Keller, 2012). In the case of RFID, in addition to attitudes towards new technologies (personal innovativeness/readiness to try), attitudes towards the protection of data privacy (personal trust), and perceived utility (relative advantage) were found to be important predictors (Müller-Seitz et al., 2009; Sill, Fisher and Wasserman, 2008).

According to a study by Roussos (2006), consumers find the collection of marketing-related information about their buying and user habits and needs through RFID more invasive than helpful. In some cases, expected benefits do not offset costs, i.e. the feared intrusion into the private sphere and the associated feeling of “loss of control” (Günter-Spiekermann, 2005). People may feel that they have the right to control the information leaving the objects they possess, while RFID deprives them of all three types of controls identified in behavioural psychology (Spiekermann, 2007): The loss of “cognitive control”

refers to the fact that consumers may be unaware of the presence of RFID tags and readers and cannot see the communication taking place. The loss of “behavioural control” means that even if they are informed about the presence of tags and readers, they cannot influence or prevent the flow of information. The loss of “decisional control” implies that consumers do not have the opportunity to choose from the various actions possible to influence the information flow, in particular if they do not accept RFID checks in or outside the store.

A recent information society attitude survey conducted in Hungary found that young adults are not particularly concerned by the various possibilities of being observed in today's society (Hoffmann, Juhász and Taskó, 2014). However, they exhibit a strong need for being capable of controlling the interactions of their electronic devices with their environment. A finding that can be important for consumers in general is that students could most effectively be convinced about the usefulness of RFID through clear communication about the benefits of the technology that included everyday examples.

In addition to privacy issues, health concerns may also become similarly relevant in the future. It is unclear today how it would affect people's health if all their items were being subjected to electromagnetic radiation. Similar concerns have arisen regarding cell phones, X-rays or living close to power lines.

On the basis of the literature, we can conclude that RFID offers some important benefits for retailers stemming from the pallet level and item level tagging of products. Applications (e.g. product tracking) along the supply chain, if used properly, will translate into higher customer value and more profits. Innovative solutions at POS, such as smart shopping carts, smart fitting rooms or self-service kiosk terminals, have a more direct impact on customer satisfaction, though they are not the most important drivers of retailer adoption today. Present and potential post-purchase applications, on the other hand, have an ambiguous effect on customer value primarily because of privacy concerns. The overall effect of RFID solutions on sales will depend on how buyers evaluate the costs of being tracked and profiled in or outside of the shop as compared to the benefits gained. Evaluation will largely be influenced by the given product or service, trust in relevant legislation, and attitudes towards information and communication technologies (ICT) and the feeling of loss of control.

4. Method

In what follows, first we present the results of an online survey conducted within the framework of an RFID research project called “Future RFID” at the EKC in Hungary in 2013. The research was supported by the European Union and the Government of Hungary, co-financed by the European Social Fund in the framework of TAMOP-4.2.2.C-11/1/KONV-2012-0014. – “Future RFID - Az RFID/NFC technológia továbbfejlesztési lehetőségei az ‘Internet of Things’ koncepció mentén”. The survey asked respondents about their attitudes and behaviour regarding relatively new technologies (including RFID) that are associated with the IoT concept. Some of the findings have been published in Hoffmann, Juhász and Taskó (2014). In this paper we report further findings, namely the relationship between consumer demography and RFID attitudes, while we also try to explore whether consumer attitudes towards RFID is influenced by attitudes towards and perceptions of ICT devices and wireless communication in general.

We then present a possible solution to the “loss of control” problem associated in the literature with the use of RFID in the retail sector. The solution, which is technological in nature, has been proposed by computer scientists of the Internet of Things Research Institute (IRI) at EKC. The findings we report are based on semi-structured interviews and informal conversations with researchers involved in the project. Our interview questions were related to the R&D efforts undertaken by IRI, and in particular the development of innovative RFID tags.

5. Results and Discussion

5.1. Consumer survey

The main aim of the survey carried out within the Future RFID project was to assess whether there are RFID-specific fears, privacy and health concerns in young adults, and how present and future ICT and RFID applications that transmit/store personal data are evaluated. The questionnaire was primarily administered to students of informatics. We obtained completed surveys from 569 people. In the analysis presented in this paper, we only included the responses of people over the age of 18 and having completed at least secondary education (N=237), as from a marketing point of view their attitudes are more relevant (table no.1).

Table no.1: The demographic distribution of the sample

		Frequency	Percent
Gender	men	143	60.3
	women	94	39.7
	Total	237	100.0
Age	18-25	124	52.3
	25-30	49	20.7
	30-50	56	23.6
	over 50	8	3.4
	Total	237	100.0
Educational attainment	secondary	120	50.6
	tertiary	117	49.4
	Total	237	100.0
Current studies	vocational	21	8.9
	BA/BSc	107	45.1
	MA/MSc	40	16.9
	none	69	29.1
	Total	237	100.0
Permanent residence	village	54	22.8
	small town	87	36.7
	large town	96	40.5
	Total	237	100.0

Attitudes towards RFID was measured with 4-point Likert scale. Based on scale item means, respondents on average had slightly positive attitudes towards RFID (table no.2). They expressed the strongest preference for being capable of controlling interactions between their electronic devices and the environment, which is supported by the fact that they were the least positive about the reliability of their environment, i.e. current legislation of information privacy and people who can gain access to private data. Indeed, the two items have a relatively strong correlation ($r= 0.48$).

Table no.2: RFID attitude scale (1=not at all; 4=absolutely)

		Mean	Mode	Std. Deviation
1	It would be important for me to be able to give permission about who and can read my devices and when.	3.09	4	0.93
2	It was a good idea to make microchips in dogs mandatory.	2.71	3	1.02
3	I would gladly buy a product with an RFID tag embedded on it if it helped post-purchase services, such as identification and repair work.	2.48	3	1.00
4	Product identification enabled by RFID has more advantages than disadvantages.	2.44	2	0.91
5	RFID has more benefits than drawbacks.	2.37	2	0.89
6	I think the threats of RFID are exaggerated.	2.34	2	0.93
7	Compared to the benefits of RFID, the problems are insignificant.	2.33	2	0.91
8	I would appreciate the spread of RFID, as it makes life more comfortable.	2.29	2	1.01
9	I don’t think I would be a target of privacy invasions or information abuse.	2.28	2	0.88
10	I would gladly use an RFID passport that makes travelling faster and helps me avoid confrontations with customs officers.	2.27	3	1.05
11	I trust that people who can gain access to my private data will not abuse them.	2.23	2	0.96
12	I think laws (will) properly regulate RFID issues.	2.06	2	0.84
13	The electromagnetic field of RFID gates can be hazardous to one’s health.	1.99	2	0.80

According to independent samples t-tests, men are significantly ($p<0.05$) more enthusiastic about the benefits of RFID and less concerned about its potential threats. Women scored significantly higher on one item only: they have more confidence in others who can gain access to data about them. Probably this is why they feel less need to control the information conveyed by their devices and products.

Using one-way ANOVA, we did not find any significant differences in RFID attitudes on the basis of respondents’ age (cohort) or geography (residence). On the other hand, some

interesting relationships were spotted between RFID attitudes and education. In general, higher levels of completed and ongoing studies can be associated with more positive RFID attitude, though except for item number 3 ($p < 0.05$), 5 ($p < 0.01$), and 8 ($p < 0.05$) the differences are non-significant.

As mentioned earlier, in addition to RFID, the questionnaire examined respondents' attitudes towards the privacy and health issues of a broad range of ICT devices and applications, including internet browsers, social networks, e-mails, Wi-Fi, mobile phones, electronic loyalty cards, and electromagnetic waves. The responses to questions on each of these issues were measured with summated Likert scales similar to that of RFID (table no. 2). The correlation analysis of summed scales found that RFID attitudes had a significant ($p < 0.01$) relationship with attitudes towards every other similar technology, and showed the strongest relationship ($r = 0.4$) with attitudes towards the threats associated with electromagnetic waves emitted by mobile phones, microwave ovens, Wi-Fi modems, etc. (table no. 3). Respondents who were less concerned about the health issues of using devices that release electromagnetic radiation were also more positive about the use of RFID. As for privacy issues, the association is most robust between attitudes towards RFID and attitudes towards mobile phones, which is not surprising, as privacy problems have been brought up concerning mobile phones that are similar to the concerns arising in the case of RFID today. We can conclude that consumers who are less concerned with the privacy and health issues of using ICT devices and applications in general are more ready to accept RFID as well.

Table no.3: Correlation among consumer attitudes towards the privacy and health issues of various ICT devices and applications (Spearman's rho and significance levels)

	RFID	Health issues of ICT	Privacy issues regarding...					
			Mobile phone	Internet browser	E-mail	Wi-Fi	Loyalty card	Facebook
RFID	1	0.402**	0.279**	0.244**	0.228**	0.213**	0.197**	0.172*
Health issues	0.402**	1	0.303**	0.244**	0.242**	0.175**	0.172*	0.215**
Mobile phone	0.279**	0.303**	1	0.302**	0.203**	0.122	0.235**	0.223**
Internet browser	0.244**	0.244**	0.302**	1	0.567**	0.03	0.169*	0.134*
E-mail	0.228**	0.242**	0.203**	0.567**	1	0.113	0.153*	0.163*
Wi-Fi	0.213**	0.175**	0.122	0.03	0.113	1	0.168*	0.232**
Loyalty card	0.197**	0.172*	0.235**	0.169*	0.153*	0.168*	1	0.148*
Facebook	0.172*	0.215**	0.223**	0.134*	0.163*	0.232**	0.148*	1

* Correlation is significant at the 0.05 level (2-tailed).

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

5.2. Improved RFID technology to eliminate the loss of control problem

As the literature review revealed, the most important bottleneck of spreading RFID in retailing is the loss of consumer control and privacy. Our survey findings also showed that consumers have a strong desire to be able to control interactions between their devices and the environment, especially as they do not trust legislation or the people who may gain access to data about them. A simple solution to the privacy problem would be to deactivate tags at the time and place of the purchase to ensure that retailers are unable to track customers and their items after customers have left the store. But deactivating tags would deprive marketers of many opportunities to increase customer value and would impose extra burdens on retailers too. Furthermore, if it were the retailers’ responsibility to deactivate tags, consumers would not be able to make sure that their tags had actually been turned off and their privacy fully respected. To resolve this privacy problem, researchers of IRI propose RFID and NFC tags that make it possible for consumers to control the flow of information between the tagged product and its environment, including the recognition of unsafe sources of information (figure no.1). The technical aspect of the solution is the extension of the Electronic Product Code Class 1 Generation 2 (EPC Gen 2) standard to include a user interface that allows consumers to detect the tags attached to the products they purchase and control the behaviour of the tags (Bánlaki, Hoffmann and Juhász, 2014). The solution would offer three alternatives for consumers: (i) not to be seen by UHF at all, (ii) both to receive and send information through UHF, and (iii) only to receive information without being able to reply.

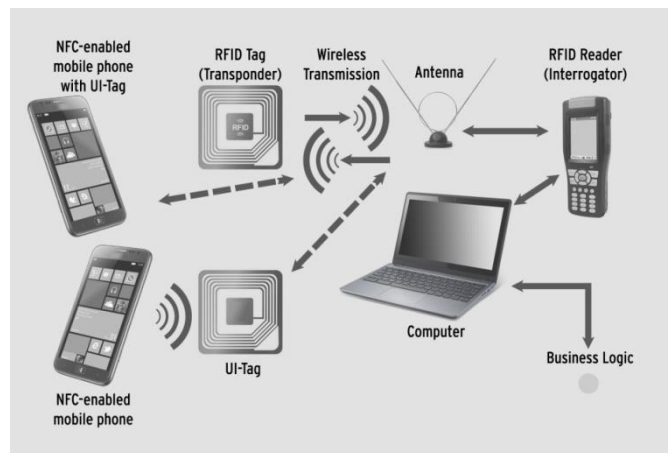


Figure no.1: The extension of the EPC Class1 Gen 2 standard to include a user interface (‘UI-TAG’)

Note. The dashed lines indicate that communication may or may not take place between the consumer and the retailer, as the consumer can decide whether or not he/she wants to be “seen” by the interrogator or not. If the mobile phone is NFC-enabled and has an inbuilt user interface (“UI-TAG”), then it can directly communicate with the reader. If the phone is not equipped with a UI-TAG, it can only communicate with transponders that have an integrated user interface.

According to the present EPC Gen 2 protocol, a tag cannot process the information it receives from the reader, but if the proposed tag were realized, consumers would be able to read the message on their mobile phones via NFC and decide whether they wanted to use it or not. In

other words, through their NFC-enabled phones including a UI-TAG, consumers would be able to control the behaviour of RFID tags embedded in the products they buy. They would be able to select when, where and from which retailers they wish to receive marketing information, and would also be able to disable the tags completely themselves, forbidding any communication that might breach confidential information. The combination of UHF and NFC is not new, but according to our present knowledge there have been no attempts to protect individual privacy by allowing consumers to communicate directly with the tags embedded in their products. The integration of this capability in the protocol could bring a breakthrough in the further development and diffusion of the technology.

Additional areas of research at IRI include applications for supply chain management, location based services and short distance communication. For example, consumers could gain information about the origin, quality, storage conditions, etc. of food products at POS through NFC-capable mobile phones, if the products were provided a unique identification code. NFC is a short-wave communication technology, so it requires the active participation of the user in communication (waving the mobile phone over an NFC compatible device), while RFID tags are automatically scanned by the reader. NFC is seen as the main enabling technology for smart phone assisted virtual wallets, already included in some models. Another interesting research area is improved product localization, which extends the original aim of RFID. Formerly, the presence or absence of objects with RFID tags could be determined with only minimal accuracy, in a relatively large estimated area. However, the technology is capable of locating objects more precisely by making use of smart antennas and protocols in a middleware layer. The improved localization of tags would also improve the quality of Location Based Services (LBS), such as discovering the nearest grocery store, gas station or ATM. According to our present knowledge, RFID has not been utilized in short distance UHF communication, when the scanning range of the reader is only a few meters. It would create value for consumers to be able to receive short-range product or promotional information from retailers. This is actually a cheaper solution than long range communication. Extending the read range of mobile phone's NFC technology to a few meters would allow consumers to use the NFC function of their phones to access information provided by UHF RFID technology. So with the help of their phones, consumers who pass by certain groups of items or the store entrance could access information sent by retailers.

Conclusions

Recent developments in information and communication technologies have given rise to a vision of a digital society entitled the Internet of Things, in which objects and even living things appear in the virtual world to interact with each other. IoT has a vast potential to improve quality of life and give new impetus for innovation and competition in the business world. A chief area of innovation is related to RFID technology, which also raises important questions regarding the security and privacy of individuals. Consumers may feel that through invisible channels of communication sellers detect their whereabouts, movements and belongings, and hence observe their health, lifestyle and habits. RFID solutions in the retail sector handle sensitive information about consumers, whose behaviour will essentially depend on their perceptions of the level of security guaranteed by sellers and the government to communication systems.

As found by our survey, among young Hungarian consumers, it would be preferable to broaden the scope of examinations to other ICT devices and applications as well, because the privacy and health concerns raised by RFID significantly relate to the same concerns regarding similar technologies that also use invisible/electromagnetic waves for communication (e.g. mobile phones). Hence attitudes towards RFID can be influenced by opinions and attitudes towards other new technologies and by the demographic characteristics of consumers, however, these relationships should be further investigated and tested.

Business organizations have an unquenchable thirst for marketing information and in particular for an accurate understanding of the complexity of consumer behaviour. Such complex knowledge about consumers would mean a significant competitive advantage, but the profit motive should be controlled by consumers' and society's interests. An important question is how and to what extent the EU and national governments should and could regulate the use and misuse of RFID tags, how possible abuses will be identified and corrected. The PIA Framework offered by the EU is a promising initiative, but it is questionable how effective the self-regulation of industries can be. The technical solution to the privacy problem described in this paper is highly relevant in the current situation, as it does not result in a trade-off between privacy and value. The new technology comprising an NFC-enabled phone and an enhanced RFID tag would allow buyers to control the communication that may take place between them, their products and the environment.

As a final remark, we believe that the key to successful RFID applications is positive customer value, i.e. when the benefits of a particular solution exceed its costs. Companies should evaluate the costs and benefits of their RFID systems from the consumer's perspective too. For example, electronic toll collection systems have not caused any protests by automobile owners, as the value of the technology (convenience) outweighed the risk of being tracked while travelling. Retailers should also try to decrease the perceived risks and increase the perceived value of using RFID through education about how and why the technology is used in a given situation. Most importantly, consumers will be more likely to accept RFID solutions that offer clear, tangible benefits for them (e.g. faster checkout, original and safe items) than ones that seem to be important for retailers only.

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