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Consumers' perceptions of item-level RFID use in FMCG: A balanced perspective of benefits and risks

Wesley A. Kukard[1], Lincoln C. Wood[2,3,*]

1. Department of Business Information Systems, Auckland University of Technology, Auckland, New Zealand.

2. Graduate School of Management, the University of Auckland Business School, Auckland, New Zealand

3. School of Information Systems, Curtin University, Bentley, Western Australia, Australia.

* Corresponding author. +649 923 5820 L.Wood@auckland.ac.nz

Abstract

This research explores how perceived consumer benefits affect the perceived privacy risks from implementation of Radio Frequency Identification (RFID) tags at an item-level in the Fast Moving Consumer Goods (FMCG) industry. Two new categories measure the benefits and risks: in-store and after-sales. These specific categories allow the respondents' willingness to accept RFID to be evaluated using a quantitative survey focused on the primary household grocery purchasers within the USA. The results suggest differences in perceptions of the in-store and after-sales risks and benefits of RFID use. While consumers' are aware of privacy risks while using RFID technology, they would be willing to use the technology if sufficient benefits are available. This research moves the discussion away from a focus on consumer privacy issues to a balanced privacy/benefits approach for consumers and how that might affect their technology acceptance, suggesting that careful management of consumer benefits might allow FMCG firms to introduce RFID technology to support their global supply chains.

Keywords: item-level RFID, Privacy concerns, fast-moving consumer goods (FMCG), Technology acceptance.

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INTRODUCTION

As technology moves forward, we will see a future where all devices are connected to the Internet – a 'connected future' (Burrus, 2014). While the concept of a connected future remains in its infancy now, it is built on an expectation of the future and our way of life. In much in the same way social media has evolved to become a fundamental part of day-to-day life, the 'Internet of Things' (IoT) paradigm will soon become embedded as a part of life over the globe, as "[b]y 2025 Internet nodes may reside in everyday things – food packages, furniture, paper documents, and more" (National Intelligence Council, 2008, p. v.). RFID technology has become synonymous with the IoT paradigm, as the technology uses wireless and uniquely identifiable chips that are low cost, easy to produce, and easy to integrate into existing manufacturing processes. Since RFID gained popularity in the early 2000s, there has been a focus to create an industry standard for RFID's Electronic Product Code (EPC). A standard would improve visibility, traceability, awareness of the chips status and current location in the supply chain – these are all key components on the path to the full deployment of the IoT vision (Atzori, Iera, & Morabito, 2010). Combined, these components provide valuable supply chain information.

To understand the implications for global firms shifting their products and services in recognition of the IoT, we focus our attention on implementation opportunities in the FMCG industry. Due to the large number of good and the way that FMCG touches the lives of everyone, this is likely where the IoT will become a part of everyday life. Nine of the top ten FMCG multinationals are based either in Europe or the United States (Statista, 2014), their reach is truly global, and their decisions impact the lives of billions of people on a daily basis. FMCG products typically have a short life cycle; item-level RFID-tags are the only feasible option to integrate FMCG products into a global IoT network.

To understand how global FMCG companies will be able to establish an IoT using RFID technology, we must first understand the role of consumer acceptance of this technology. Given the United States and European base for the global FMCG firms, we assume that the appropriate technology will be first tested and deployed in such wealthier and more technology-savvy marketplaces. Therefore, understanding whether consumers in these home markets will accept and adopt the RFID technology becomes central to whether or not the FMCG firms can effectively establish an IoT. Then, as the technology is adopted around the globe, the FMCG firms will be effectively positioned to manage the global flows of products and information. All these commercial benefits, however, require FMCG firms to understand and be effective custodians of consumer data in a way that alleviates any consumer concerns about information privacy.

Consumers are more likely to be accepting of a technology that can drive benefits (Östman, 2013), without undue risk to themselves. Some retail outlets now use fast self-checkouts or are eliminating checkouts altogether through the use of RFID; while these changes represent a cost saving to the retailer (Prater, Frazier, & Reyes, 2005), the consumer would gain only a minor time-saving as a benefit. What is required are some substantial after-sales benefits for consumers. However, most after-sales benefits require RFID tags to remain active after purchase, potentially opening up consumers to unauthorized data collection within their home. Smith, Milberg, and Burke (1996) identify four dimensions of information privacy: collection, secondary unauthorized access (internal/external), improper access, and errors.

This research is important as it focuses on consumers' perceptions of risks and benefits of RFID use, in contrast to industrial perspective or a focus only on perceived risks. While much research has focused on industrial adoption and acceptance of RFID, this leaves open the question: At what point does household technology overstep the privacy boundary? An ever increasing amount of consumer electronic devices being integrated with various sensors, cameras, microphones and internet nodes to upload and use the collected data. There is a strong connection between IoT and RFID (Anderseck et al., 2012), as RFID is low-cost and uniquely identifiable, and can, therefore, keep track of lower cost disposable items, turning them from everyday grocery items, into smart grocery items. However, most research on RFID in the retail sector focuses on risks. There has been limited focus on benefits, despite growing consumer acceptance of related wireless technologies like NFC due to benefits. Smith et al. (2013) come the closest to measuring how RFID-related benefits could affect consumers' perceptions but was limited to evaluating benefits/privacy risks within a store environment. In contrast, in this research we examine both 'after-sales benefits' and 'after sales risks', allowing us to establish how perceived benefits and perceived risks affect the consumers' willingness to accept item-level RFID in both the in-store and home-based environments.

The research question we aim to answer is: How do grocery buyers perceive the balance between the benefits and risks of RFID acceptance at an item-level within the FMCG industry? Answering this question involves determining whether consumers would be likely to accept a level of risk associated with RFID at an item-level in the FMCG industry if the benefits were great enough. Specifically, we distinguish between in-store and after-sales risks and benefits and examine their impact on consumer acceptance of RFID use at the item-level in the supermarkets. Being able to distinguish between these risks is important for global FMCG firms as they seek to distribute products globally and manage this information to improve their network of product and information flows.

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In the next section, we review applications of RFID with a focus on security and privacy and both after-sales risks and benefits from a consumer perspective. Subsequently, we outline the survey that was undertaken to address the research question and present the results before discussing these results. We then present our conclusions and suggestion future research directions.

LITERATURE REVIEW

The development of global information networks supporting FMCG adoption of RFID and the IoT depends on consumer acceptance of the technology. Therefore, we first review past research on RFID use, focusing specifically on privacy and security issues in RFID adoption. We examine technology approaches to solve these issues and also review consumer acceptance literature.

Applications and Research Trends in RFID

The potential applications for RFID within the grocery store environment are diverse, with the potential to add value for manufacturers, retailers, and consumers (McHugh, 2004; Östman, 2013). This research will highlight some of the applications that could benefit the FMCG industry and their consumers. The conventional industry benefits include inventory management, shrinkage reduction, theft reduction, reduction in food waste or deterioration, and faster checkout processing (Angeles, 2005; Duong, Wood, & Wang, 2016; Jones, Clarke-Hill, Hillier, & Comfort, 2005; Li, Visich, Khumawala, & Zhang, 2006; McHugh, 2004; A. D. Smith, 2005; Taghaboni-Dutta & Velthouse, 2006). Other benefits are associated with building a better understanding of their customer base to personalize advertising, shopping lists and ultimately sell more goods (Albrecht, 2005; Alt et al., 2009). The main obstacles facing widespread adoption are the perceived privacy and security issues surrounding RFID, both in academic literature and mainstream media. The adoption of NFC – a related, wireless technology – has been far more successful than RFID as a whole, although, they are in essence the same technology. However, NFC has been marketed with a focus on consumer benefits, allowing the quick pairing of devices, thus saving time and being relatively easy to use. NFCs success lays the groundwork for large-scale RFID implementation through benefits promotion.

Past research has focused on privacy and security issues. Major RFID-related research between 2002 and 2007 was primarily (68% of publications) focused on security and privacy mechanisms for RFID, with 97 papers listing end-user privacy as the main motivation for their research (Spiekermann & Evdokimov, 2009).

Privacy and Security with RFID

One of the major continuing conversations with RFID research is the potential for mass data collection on a level that, in theory, could cause major privacy issues for consumers. When RFID tags are introduced at an item-level, the ability to track objects or consumers through their use of the items could become a lot easier. The introduction could lead to consumers becoming responsible for the objects they purchase, information collection while within stores to build a personalized advertising campaign or objects that punish misbehavior and criminals using the system to their advantage. These types of privacy concerns are well-documented (Bélanger & Crossler, 2011; Lockton & Rosenberg, 2005; Spiekermann & Evdokimov, 2009; Frédéric Thiesse, 2007). Various solutions have been proposed to either curb or completely remove the perceived potential privacy risks (Garfinkel, Juels, & Pappu, 2005; Juels, Rivest, & Szydlo, 2003; Ohkubo, Suzuki, & Kinoshita, 2005).

Garfinkel, Juels, and Pappu (2005) present some theoretical scenarios stemming from the implementation of RFID. They identified three main contexts for the use of RFID tags. First, "Inside the Supply Chain" from manufacture until delivered to the final retail outlet. Second, the "Transition Zone", which covers the customer-facing portion of the retail outlet in which the RFID enabled the item, is being sold to the consumer (i.e., what we define as in-store risks). Third, "Outside the Supply Chain", this includes all locations beyond the "Transition Zone" including the consumers' home (i.e., what we define as after-sales risks).

Two of these three main zones provide points of direct interaction between consumers and item-level RFID. According to Garfinkel et al. (2005), this could be a personal privacy nightmare for consumers as tags could be associated with a unique identity. As an example, high-value consumer items (e.g., razor blades), once removed from shelves could engage a security photograph of the consumer to later determine whether shoplifting occurred. A location threat may emerge from individuals carrying unique tags that, once scanned, could reveal their location and provide a connection to a personal profile. A preference threat might be that thieves could identify potential targets by scanning their victim from a distance to identify any high-value items and targeting them.

A framework is proposed for assessing system security and privacy risks for RFID systems (Rotter, 2008). Possible consumer risks include Eavesdropping, Relay attacks, Unauthorized tag reading, Tag cloning, People tracking, Tag content changes, Malware, RFID systems breakdown, Tag destruction, Tag blocking, Tag jamming and Back-end attacks. A key privacy risk is the connection of information on the tag to an individual's identity

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(Rotter, 2008). Thus, only items directly associated with an individual's identity pose a privacy risk. Such items could include, RFID tagged items purchased through a retail environment that is somehow linked to the purchaser or a registered identification card. Only in very specific instances do these factors affect a person's security or privacy (Rotter, 2008).

Technical Solutions to Privacy Risks

In response to public concerns relating to after-sales control of RFID, various theoretical Privacy Enhancing Technologies (PET) have been developed. Spiekermann and Evdokimov (2009) reviewed publications related to security and privacy issues facing RFID implementation, particularly focused on tag-reader security. Five PET categories have been identified: RFID-kill function, physical privacy, on-tag function, agent schemes, and user schemes. Killing the tag is seen as the most appropriate privacy-protecting approach (Garfinkel et al., 2005; Juels et al., 2003; Ohkubo et al., 2005). However, it is also recognized that this limits any potential after-sales benefit to consumers (Garfinkel et al., 2005).

Consumer perceptions of potential privacy protection mechanisms are evaluated in Rothensee and Spiekermann (2008), based on an introductory film about RFID. Although the films were unbiased, in theory, no real world consumer benefits were identified within the videos. The videos merely served to explain RFID and how it is being used within the FMCG environment. Participants were implicitly directed to focus on risks by having them rank potential privacy measures based on what they thought would be the most effective. The research showed that some consumers place a higher value on some of their personal information than other participants. Later, Spiekermann and Evdokimov (2009) highlighted and critically evaluated potential PETs. These fears include personal belongings could be assessed without prior knowledge or consent, consumers might become known and classified by others, people could be tracked and followed, consumers could be victimized, someone could be made responsible for each object that he or she owns, and people could be restricted or exposed through automatic object reactions.

Both positive and negative aspects of RFID must be considered, and the risk of harm may be an important determinant of acceptance of the technology (Cazier, Jensen, & Dave, 2008).

Proposed Consumer Acceptance of RFID Models

A key model for the consumer acceptance of RFID is based on the Technology Acceptance Model (TAM) (Hossain & Prybutok, 2008). Five factors crucial to acceptance are Perceived Convenience, Perceived Culture Influence, Perceived Privacy, Perceived Regulations Influence and Perceived Security. Each of these measures is then used to determine the consumer's intention to use RFID. A survey was conducted on 256 students, of which the results found that higher perceived convenience of RFID technology leads to greater acceptance of this technology, societal beliefs, value systems, norms, and/or behaviors influence the extent of consumer acceptance of RFID technology and higher perceived importance of and less willingness to sacrifice personal information security lead to lower intention to use RFID technology.

An adapted TAM focused on the consumer acceptance of RFID includes a 'Security Concerns' construct (Müller-Seitz, Dautzenberg, Creusen, & Stromereder, 2009). The addition of this construct balances the perceived consumer benefits and security concerns within the electronics retail environment. The subsequent surveys to test the model identified issues surrounding the challenges facing widespread RFID adoption. The results of the study show "that customer acceptance of the innovative RFID technology depends considerably on its perceived usefulness […] the second most important factor for the acceptance of the RFID technology is customers' general attitude toward the protection of data privacy" (Müller-Seitz et al., 2009, p. 31). Similarly, using a survey Trocchia and Ainscough (2012) establish that the variables that influence consumers' attitudes towards RFID tracking of their purchase behavior include:

1) Consumers do not want to be tracked beyond the retail environment regardless of the incentive offered.
2) Financial compensation was not able to induce consumers to participate in RFID programs in which they were not otherwise predisposed to participate.
3) A time-saving checkout lane was not able to induce consumers to participate in RFID programs in which they were not otherwise predisposed to participate.
4) Men were more likely to find RFID programs appealing than women.
5) Older consumers were less willing to participate in RFID programs than their younger counterparts.

While at first glance, these findings may appear negative for research into item-level tagging, the focus in Trocchia and Ainscough (2012) was on the benefits gained by the 'retail owner' as opposed to the 'consumer'.

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Consumer Benefits from RFID

Three key papers have considered consumer benefits from RFID technology (Lee, Fiedler, & Smith, 2008; J. S. Smith et al., 2013; Frederic Thiesse, Al-Kassab, & Fleisch, 2009). The academic conversation surrounding consumers and RFID is heavily weighted around the potential privacy risks of the technology, while not considering the potential benefits to consumers.

A novel approach to using RFID to add value is presented in Lee, Fiedler and Smith (2008), suggesting a customer-facing diffusion model rather than the traditional supply chain efficiency approach. RFID can be used to add intangible value to an item or service, thus increasing customer loyalty or customer satisfaction. Three case studies were presented and examined to develop the model. First, RFID in a public library was used to add a self-checkout service, reducing the number of staff dedicated to checkout and improving the simplicity of the self-checkout service. Second, a road race timing system was automated, decreasing the number of volunteers, and providing runners with more accurate results. Third, a hospital patient tracking system, demonstrated improvements in the check-in of patients, the link between patient medical records and getting the right patient the right asset at the right time. All of these benefits could be considered 'in-store' benefits as they are internal to the organization being studied. There was no examination of benefits external to the organization, the after-sales benefits.

A major European department store participated in two RFID trials, one in 2003 and another in 2008 (Frederic Thiesse et al., 2009). The main objective of the first trial was to examine to what extent RFID could create efficiency within supply chain operations under real-world conditions. The second trial extended the RFID implementation into the retail side of the department store; now offering customers the ability to engage with RFID via smart-shelves, mirrors, monitors and in-store mobile devices. Implementing RFID at a retail level and allowing customers to interact with items before purchase, could create value in a retail environment. A limitation of the study is that all benefits were limited to in the retail environment, and examples were limited to the fashion retail environment. Additionally, no after-sales benefits were examined. The study was one of the first case studies of a large-scale RFID rollout within the retail environment. Of particular interest was the way that they demonstrated that there could be a business case for engaging consumers by adding value to their shopping experience. While privacy considerations were not a part of the case study, the department store noted only three customer complaints of privacy issues during the trial period.

Consumer's acceptance of RFID could be positively impacted through perceived usefulness of the technology (J. S. Smith et al., 2013). The perceived usefulness weighs more heavily on consumers' acceptance than the associated perceived risks and that consumers are still adverse to name RFID when used at an item-level, but a privacy statement from the company could help reduce this negative attitude and therefore improve acceptance of the technology. RFID is explored from consumers' perspectives with three studies.

First, a semi-structured qualitative preliminary study involved 57 Masters of Business Administration (MBA) students who would be familiar with RFID technology. The results indicate that the respondents could see the benefits of the technology, but the study results may be representative of the general public as all respondents were MBA students familiar with RFID.

Second, the promotional and preventative concerns noted by consumers are examined using a survey. The results show that the type of message received related to the technology, either positive or negative, impacts subsequent evaluations.

Third, they focused on the increasing consumer acceptance, by alleviating privacy concerns associated with RFID. The concerns were alleviated by providing consumers with a privacy statement before the survey, allow the consumers to understand what information is being collected and what will be done with it. A total of 104 general consumers were used as participants. When the results were analyzed, they showed that the consumers presented with the 'new technology' label had higher purchase intentions to those presented with the 'RFID' label. Respondents would be more willing to accept the technology if presented with a privacy statement from the organization.

AIM AND OBJECTIVE

Research Model and Hypotheses

From the current research, we can identify the research gap that is to what degree the perceived benefits of RFID at an item-level will affect consumers' perceived risks and whether there a difference between the benefits/risks within a store environment and the benefits/risks after the item has been purchased.

As there was no differentiation between the types of potential consumer benefits and their differing associated risks, both in-store and after the sale, the model in Smith et al. (2013), can be expanded to provide further insight into consumer acceptance of RFID after the purchase has been completed. Differentiating between these two types

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of benefits available to consumers allows for a greater understanding of how consumers might react to RFID at an item-level and to what degree they are willing to accept its integration into their everyday lives. Potential benefits to consumers are split into two separate categories, in-store benefits, and after-sales, as consumers' expectation of privacy would change depending whether they are using benefits associated with RFID technology in a grocery store or at home. Below are some examples of what would be considered benefits in each of the categories.

In-Store and After-Sales Benefits

Consumer in-store benefits are those, which a consumer would consider of value while in a store environment. For example, smart shopping cart, instant coupons, suggested complementary items, returning an item without a receipt, detailed item information (environmental impacts / nutritional information), rapid self-checkouts, item reviews, and interactive promotional displays.

In contrast, after-sales benefits consist of value added while at home or otherwise away from the store and are available after purchase. For example, budgeting assistant, recipe suggestion, shopping list generation, real-time access to a kitchen inventory, company promotional interaction (competitions), and a meal planner based on dietary requirements/workout regime. The benefits provided are theoretically possible examples based on RFID implemented at an item-level and coupled with smart appliances and kitchens integrated with medium-range RFID readers.

These In-store Benefits (ISB) and After-Sales Benefits (ASB) will measure the consumer's Perceived Benefits (PB) of RFID within the Fast Moving Consumer Goods Industry (FMCG).

H1: In-store benefits will have a positive influence on consumers' perceived usefulness of RFID

H2: *After-sales benefits will have a positive influence on consumers' perceived usefulness of RFID*

Therefore, this research posits that a combination of both in-store and after sales benefits will indicate the perceived benefits of RFID will provide a similar result when used at the item-level within the fast moving consumer goods industry. PB is a contextualized version of the TAM-based Perceived Usefulness (PU) construct (Davis, 1989). As perceived usefulness (PU) is a well-accepted indicator of consumers' Technology Attitude (TA). This research posits that the PB will have a positive influence on consumer's technological attitude towards RIFD for fast moving consumer goods.

H3: Perceived usefulness of RFID will have a positive influence on technology acceptance of RFID

Similarly to the PB, the Perceived Risks (PR) are separated into two types of risks, In-store Risks (ISR) and After-Sales Risks (ASR). This separation is justified as consumers' expectation of privacy within a shopping environment will differ from their expectation of privacy at home. Trocchia and Ainscough (2012) present a compelling argument as to why consumers may be prepared to have a lower expectation of privacy in a grocery store and a much higher expectation of privacy in their home:

> Legal [academics] have said that a "reasonable expectation of privacy" exists when a person has "exhibited an actual (subjective) expectation of privacy" and, second, that the expectation is "one that society is prepared to recognize as reasonable. Thus, a man's home is, for most purposes, a place where he expects privacy, but *objects, activities, or statements that he exposes to the plain view of outsiders are not protected, because no intention to keep them to himself has been exhibited*" […] Similarly, consumers may be less sensitive to such violations in locations in which such expectation would not reasonably exist, such as a grocery store sales floor (Trocchia & Ainscough, 2012, emphasis added)

Therefore, as there are clearly two separate expectations of privacy, then this differential level of sensitivity suggests that while consumers may be more willing to forgo privacy in a shop they may be more sensitive to forgoing privacy at home.

H4: In-store risks will have a negative influence on consumers' perceived risks of RFID.

H5: After-sales risks will have a negative influence on consumers' perceived risks of RFID.

These hypotheses (H1, H2, H4, and H5) serve as the measure for the PB and PR for this model. As consumers' RFID acceptance is still a relatively untested subject, other higher risk new technology platforms were explored,

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for example, the adoption of online banking. In the case of our proposed model, Perceived Usefulness (PU) can be equated to Perceived Benefits (PB), which will indicate a positive influence on overall Technology Acceptance (TA).

The perception of risk has been recognized as influencing consumer adoption. For example, Roy, Kesharwani, and Singh Bisht (2012, p. 303) explored the impact of perceived risk on online banking acceptance; the findings were "that perceived risk has a negative impact on the behavioral intention of internet banking adoption." So, it can be assumed that in the proposed model, Perceived Risk (PR) will have a negative influence on Technology Acceptance (TA).

H6: Perceived risks will have a negative influence on technology acceptance of RFID.

Both PB and PR will directly affect the overall Technology Acceptance (TA) of RFID, which as the TAM dictates will have a direct impact on consumers' overall Intention of Use (IOU), giving the final hypothesis as part of the model in Figure 1.

H7: The overall positive or negative perceptions of RFID will affect the intention of use the technology at an item-level

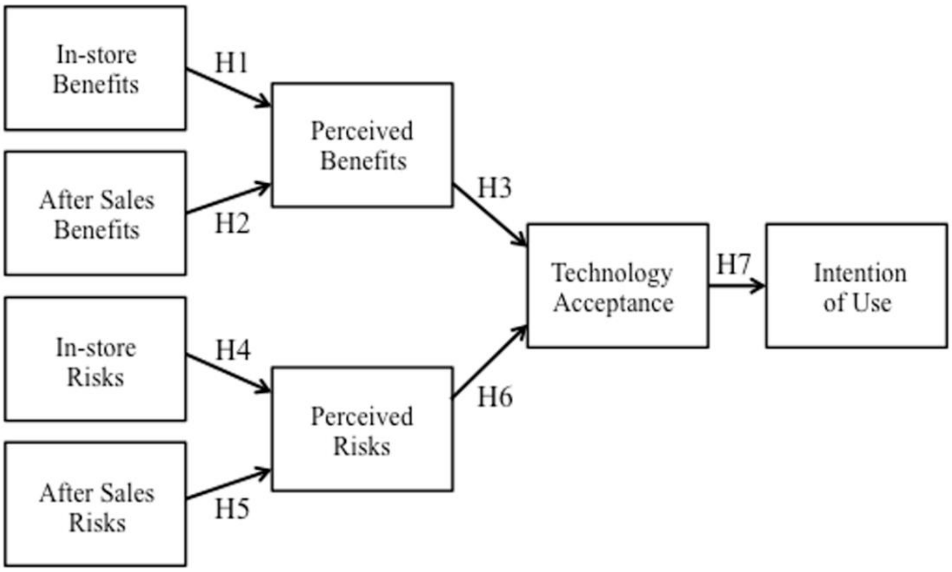

Figure 1. How in-store and after-sales benefits/risks affect consumer's RFID acceptance

METHODOLOGY

Due to the nature of our research topic on RFID use at an item-level within the FMCG industry, we anticipated consumer privacy concerns (McCullagh, 2003). Therefore, we opted for a quantitative approach was used to measure and evaluate acceptance of a hypothetical RFID technology. When people are presented with new technology, in this case, RFID-enabled smart groceries, the novelty of the technology could skew the results. A quantitative survey allowed the questions to be structured in a way to minimize bias and could be conducted through a US-based research company. As this research is using an experimental model with the goal of measuring consumer perceptions to predict potential technology acceptance in a reliable and repeatable manner, the use of quantitative methods to test these hypothetical generalizations is the best solution (J. K. Smith, 1983).

Data Collection, Instrument Design, and Construct Measurement

To test the validity of the model, a large-scale data collection was undertaken via an online structured survey. This research sought to improve on the J. S. Smith et al. (2013) questionnaire, which had no differentiation between the consumers' perceived usefulness in-store and after-sales. This differentiation is key to understanding to what degree consumers will accept such an invasive technology on such a large scale. The data in J. S. Smith et al. (2013) was collected from MBA students, of which many already had a good understanding of the workings of RFID; this is limitation means that those results are not necessarily a true reflection of a general consumers'

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acceptance.

For the survey, a five-point Likert-type scale was used, ranging from 1 (indicating strong agreement) to 5 (indicating strong disagreement). The questions were situational, putting consumers in hypothetical scenarios where they would be interacting with this new wireless technology and being told the potential benefits or risks. (A copy of the survey is included in Appendix A.)

While many items were adapted from Smith et al. (2013), new questions for the latent constructs of in-store / after sales benefits/risks, while not previously tested or validated within the literature, were based on the *reasonable expectation of privacy* theory (*Katz v. United States - 389 U.S. 347*, 1967); while in a public place, such a grocery store a person has a lesser expectation of privacy, as opposed to at home, where someone would have a definite expectation of privacy. The structured survey asked respondents to rate the potential benefits and risks of "a new smart grocery technology." The use of the term 'RFID' was intentionally avoided due to possible consumer negative associations and biases (e.g., as identified by J. S. Smith et al. (2013)). A pilot test of the survey was conducted with 20 postgraduate students to identify any potential biases. Feedback indicated that we should pair of positive and negative questions to reduce bias within the survey from the 'order effect' (Steinberg, 2001).

Ethics

An application was made to the University Ethics Committee, outlining the research aims and objectives, background, proposed data collection and analysis, and handling of data. An online survey research company provided a quote to distribute and collect anonymized data from their existing survey panel, based on members that met the predetermined demographic criteria of the survey (in this case, household grocery decision makers between the ages of 18 and 65). Respondents received no direct compensation for completing the survey but instead a small donation was given to a charity of their choice.

Data Sources and Analysis

A quantitative approach was taken through a large-scale data collection via an online survey research company. The respondents were based in the United States; this demographic would be likely to be among the first to be exposed to this type of technology, and it allows our results to be more directly compared to extant research (as this often used a US-based sample). 264 initial responses were received from the respondents.

After the data had been collected, it was analyzed using Partial Least Squared Structural Equation Modeling (PLS-SEM) (Henseler, Ringle, & Sinkovics, 2009). PLS-SEM was preferred to accommodate a more exploratory analysis of relationships between attributes have not been previously tested (Ainuddin, Beamish, Hulland, & Rouse, 2007). As we use three indicators for each construct, we opted to target a sample size of 250, which should yield an R^2 of 0.10 and a significance level of greater than 1% (Hair Jr, Hult, Ringle, & Sarstedt, 2013). PLS-SEM estimates the path model relationships that maximize the R^2 value of the endogenous constructs, minimizing unexplained variances, which allows for better theoretical model development (Hair Jr et al., 2013). Therefore, it was a better fit with our objectives than covariance-based SEM (CB-SEM, often used in confirmatory studies).

ANALYSIS AND MODELS

Demographics and Descriptive Results

In total, there 264 responses; after careful analysis of responses, 16 responses were discarded as they were invalid, leaving a total of 248 responses used in the analysis. The discarded responses were considered invalid for several reasons. Exploratory analysis indicated that there were 13 responses where the same answer was selected throughout the entire questionnaire. One respondent declared they were not the household buyer, invalidating their response. Demographical data is provided in Table 1.

As 56% of young adults aged 18 to 24 still live at home with their parents (Fry, 2013), we, therefore, expected more grocery buyers to be in an older age group. The small number of respondents falling into the 18-25 age range was therefore not a concern.

<<Insert Table 1 here>>

Table 1. Demographics Data

Overall, the sample was primarily female (66.5%) over the age of 45 (70.9%). There was an even distribution of respondents' level of education, with 25.8% of them had completed high school, 21% had some college education, but no degree and 21% had graduated from a college. 75% of surveyed household income is under $70,000pa. Table 2 compares the sample to the household income of the 2011 United States Census (US Census Bureau, 2012) showing general similarities.

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<<Insert Table 2 here>>

Table 2. Household Incomes – Sample Vs. 2011 US Census

Data Validation

To evaluate the proposed model, the PLS-SEM evaluation process outlined in Hair et al. (2013) was followed to ensure that all necessary measures for validation were met (e.g., internal consistency reliability, convergent validity, and discriminant validity). Validating the proposed model through this process ensured reliable and repeatable results for future research.

Reflective indicators examine an underlying construct that is unobservable as opposed to an indicator in which case it determines the construct (Petter, Straub, & Rai, 2007). Our research model consists of eight reflective constructs including, *in-store benefits* (ISB), *after sales benefits* (ASB), *in-store risks* (ISR), *after sales risks* (ASR), *perceived benefits* (PB), *perceived risks* (PR), *technology acceptance* (TA) *and intention of use* (IOU).

Testing the internal consistency reliability is typically the first criterion to be evaluated. In this instance, composite reliability (CR) was used to test the model. Results vary between 0 and 1; usually, a higher value indicates a higher reliability (Hair Jr et al., 2013). The results indicate a range from 0.856 to 0.977 (Table 3). Most results are all within an acceptable range of 0.70 and 0.90. However, two constructs have an undesirable result of above 0.95 (Hair Jr et al., 2013). Technology acceptance (TA) and intention of use (IOU) indicate 0.965 and 0.977 respectively. However, under these circumstances, the constructs have been derived from Davis (1989), and they have been proven to be solid and reliable constructs.

<<Insert Table 3 here>>

Table 3. Internal Consistency Reliability Results

Convergent validity measures the positive correlation between a construct's indicator and the alternative indicators of the same construct; we tested this by considering the outer loadings of the indicators as well as the average variance extracted (AVE). The recommended acceptable value of the AVE should be 0.50 or higher (Hair Jr et al., 2013). Our results are all within the acceptable value, with AVE ranging from 0.665 to 0.933 (Table 4), suggesting that the convergent validity is confirmed.

<<Insert Table 4 here>>

Table 4. Convergent Validity Results

Discriminant validity was checked to determine to what extent each of the constructs were distinct from each other. The check was conducted using the Fornell-Larcker criterion (Fornell & Larcker, 1981) that compares the square root of the AVE values with the latent variable correlations. The square root of the AVE value should be higher than that of its highest correlation with any other construct (Hair Jr et al., 2013). Table 5 shows the construct's outer loadings and cross-loadings. In all cases, the outer loadings are higher than the cross loadings, indicating that each indicator was measuring a unique concept, and there was no need to remove any indicators from the proposed model.

<<Insert Table 5 here>>

Table 5. Discriminant Validity Results. The shaded diagonal values are the square root of the AVE extracted for each construct; in each case these values exceed the highest correlation with any other construct to fulfil the Fornell-Larcker criterion.

RESULTS

Structural model validation measures proposed model constructs and allows it to be compared with the theoretical measure model and sample data (Hair Jr et al., 2013). Full outputs of the PLS-SEM results are shown below in Figure 2. The next step is to assess the statistical relevance of the loadings and path coefficient. The PLS bootstrap procedure was used to draw a large number of additional samples from the original sample at random with replacement. For our bootstrap procedure, 5000 bootstrap samples were used (Hair Jr et al., 2013). Bootstrapping also provides R^2 values, which assesses the reliability of the model; results are shown in Table 6.

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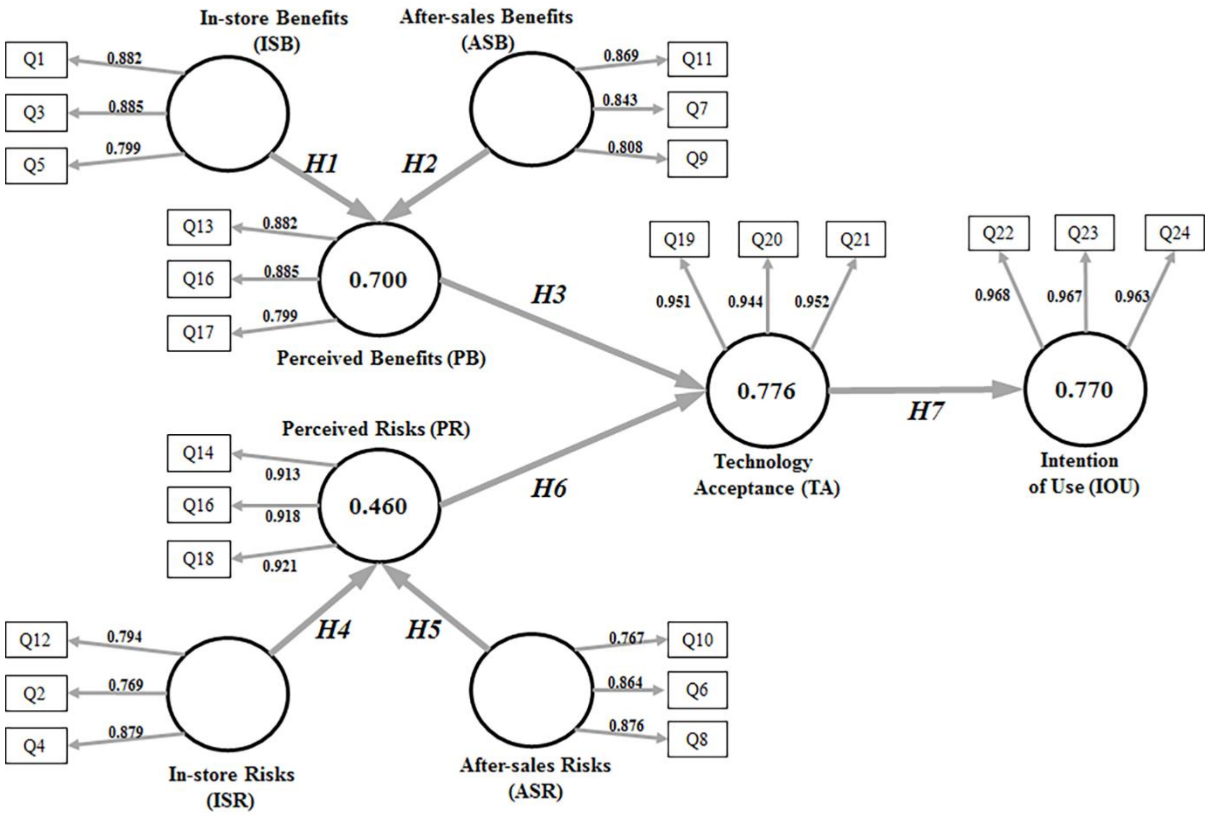

Figure 2. PLS-SEM modeling results

The most common method used to evaluate the structural model is the coefficient of determination (R^2 value), measuring the model's predictive accuracy and is calculated as the correlation between a specific construct's actual and predicted values (Hair Jr et al., 2013). The structural model's R^2 values are presented in Table 6; all values exceed the required minimum values of 0.75 as only consumer perceptions and their potential behaviors are being measured (Hair Jr et al., 2013). The strongest relationship is Technology Acceptance (0.775), followed by Intention of Use (0.769), then Perceived Benefits (0.698), and Perceived Risks with the lowest value (0.456).

<<Insert Table 6 here>>

Table 6. R^2 Value for the Constructs

1) In-store benefits and perceived benefits
Table 8 shows a strong relationship between potential in-store benefits and consumers' perceived usefulness of RFID technology (path coefficient=0.524, t=10.777, p<0.000). These results indicate that H1 is supported.

2) After-sales benefits and perceived benefits
There is a moderate relationship between potential after sales benefits and consumers' perceived usefulness of RFID technology (path coefficient =0.382, t=7.656, p<0.000). Therefore, H2 is supported.

3) Perceived Benefits and technology acceptance
The relationship between consumers' perceived benefits of RFID and the acceptance of the technology has a significantly strong relationship (path coefficient =0.732, t=22.186, p<0.000). Therefore, H3 is supported.

4) In-store risks and perceived risks
There is a weak relationship between in-store risks and consumers' perceived risks of RFID technology (path coefficient =0.236, t=3.165, p<0.02). This relationship is weaker than the others due to consumers' having a lower expectation of personal privacy while in a public/in-store environment. The weakness of the relationship may mean that, either consumers' are unaware of the potential risks or are not as concerned with potential in-store risks. Hence, H4 is supported.

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5) After-sales risks and perceived risks

There is a moderate relationship between the after sales risks and the perceived risks of RFID technology (path coefficient =0.475, t=6.800, p<0.000). Therefore, H5 is supported.

6) Perceived risks and technology acceptance

There is a moderate inverse relationship between the perceived risks of RFID technology and its technology acceptance (path coefficient =-0.260, t=7.232, p<0.000). Therefore, H6 is supported.

7) Technology acceptance and intention of use

There is a strong relationship between the technology acceptance of RFID and the consumer's intention of use (path coefficient =0.878, t=54.666, p<0.000). Therefore, H7 is supported.

DISCUSSION

This research focused on the consumer acceptance of RFID implementation within the FMCG industry and how the perceived benefits of the technology could outweigh any perceived risks. No other research has actively given such consideration to reasons for consumers' desire the adoption of the technology beyond the checkouts. This research survey gave examples of both the potential benefits and potential risks to consumers.

This paper hypothesized that consumers would be more willing to accept RFID technology at an item-level within the FMCG industry if they felt the potential benefits outweighed the potential risks in the technologies implementation.

The first hypothesis was supported, indicating tat consumers within a grocery store environment will view the implementation of RFID as positive as long as they gain a sufficient benefit. The second hypothesis was also supported, meaning, if these benefits continue into the home, consumers will remain positive about RFID, despite the potential risks. They will also have an overall positive view of the technology as the third hypothesis was also supported. These findings are important, as they extended the analysis and recognized the importance of benefits outside of the store, by recognizing after-sales benefits as a distinct category in a way that has not been clearly addressed in prior research (e.g., Lee et al. (2008)). Indeed, while not as important as the in-store benefits, the after-sales benefits do have a relationship with the consumers' perceived benefits. In contrast to Frederic Thiesse et al. (2009), where few privacy issues were noted – it is important to recognize that these privacy issues may also occur later, after-sales, and it may then be less likely that a consumer would lodge a complaint or register their concern.

The fourth hypothesis was supported although this was a weak relationship. Therefore, in a grocery environment, consumers will not feel that there are significant privacy risks while using the technology as there was no reasonable expectation of privacy while shopping in such a public place. While privacy may not be an issue in public, the fifth hypothesis showed that consumers would consider RFID a privacy risk while in their home and that overall, the potential risk would have an overall negative influence on the technology. Interestingly, this was one of the weaker relationships, and this indicates that consumers are more able to overlook in-store risks and 'discount' these when evaluating the technologies; instead, they perceive the after-sales risks to be more important. Therefore, our results are well-aligned with greater expectations of privacy within the home rather than in the store.

However, the after-sales risks as perceived risk have an $R^2 = 0.456$ (Table 6), indicating that this model explains 45.6% of the variance in the construct; therefore, there could be other contributing factors that may affect after-sales adoption other than perceived risk. Overall, the survey results indicate that our conceptualization of risks can be further improved as there may be other factors that have been overlooked in this model and there may be other moderating or mediating factors at play.

Hypothesis seven was supported, indicating that the combined benefits and risks would give a good indication of the likelihood of consumers to adopt RFID.

Overall, while consumers seem to be aware that there could be a certain degree of risk while using RFID both in-store and after-sale, they would still be willing to use the technology if there were sufficient benefits. These results draw on a broad spectrum of society and therefore should be more generalizable than the comparable survey was undertaken in Smith et al. (2013), where MBA students were the respondents. Overall, while Smith et al. (2013) found that privacy risks were negatively impacted, these were not as significant as expected in our study. Given our results, we believe that this may be partly due to how the risks have been measured and evaluated. By splitting risks into in-store and after-sales, we believe the survey instruments and concepts are more clearly defined and measured. Indeed, we find that while there are in-store risks perceived by consumers, it is the after-sales risks that will be most important for RFID implementations to address through effective communication and education of consumers about what to expect and how to address any concerns.

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Contributions to Research and Practice

By exploring consumer acceptance through the balancing of the benefits and risks of RFID, a new conversation can emerge. It is worth noting that this has previously been mentioned as a gap in the literature, as there is wide recognition that the TAM model still requires refinement (Müller-Seitz et al., 2009).

Our framework differentiates between in-store and after-sales measures for consumer benefits and risks. Therefore, this research develops insight into the first of two important factors influence consumer acceptance. First, customers must be aware of a specific usefulness that outweighs the potential disadvantages of the technology. Second, customers must believe that the novel technology is secure (Müller-Seitz et al., 2009).

We find that when consumers are given sufficient benefits they can look beyond potential privacy risks associated with RFID technology. This weighting of benefits relative to risk has a major impact on how researchers could create models for RFID integration for a controlled and scalable integration into the supply chain. For example, a bottom-up strategy could be used to test how consumers react to RFID implementation in different item categories. If successful, implementation could be expanded to other item ranges, categories and further up the supply chain, eventually creating an entire RFID enabled eco-system.

Overall, this research expanded RFID literature by questioning the current conversation that focused on privacy risks for consumers and asked what if consumers were able to gain sufficient benefit for RFID at an item-level, that the potential privacy risks were a non-issue. There is now a framework for future researchers to measure consumer acceptance of RFID at an item-level within the FMCG industry.

Our results suggest that professionals in the FMCG industry should consider an alternative method for the item-level implementation of RFID. An effective implementation may include a bottom-up approach, including RFID on certain item-level products, solely for the benefit of the consumer that these benefits should be very visible. For example, promotions, item information, suggested items, or coupons. This approach is scalable, ensuring manufacturers/retailers have the ability to control the initial rollout, select the potential value for their businesses and gain an understanding of what benefits are gained from the roll-out as well as the cost of further implementation. This approach gives manufacturers valuable insight into how their consumers use the technology and how they can incorporate consumer benefits into the overall architecture of their RFID system.

This research identified the benefits a potential consumer would find most useful, allowing them to overlook the potential privacy issues in exchange for these benefits. Managers can tailor the potential benefits to cater for what consumers' would find most useful, making the roll-out of this new technology much more likely to be accepted.

LIMITATIONS AND FUTURE STUDIES

There are several limitations in this study. First, the survey asked for opinions based on a hypothetical technology rather than their opinion of an existing technology they have experienced. Our research followed the approach taken in Smith et al. (2013). The respondents had to consider their answers based on scenarios (potential benefits / potential risks) presented to them within the survey. The survey was constructed from previous RFID acceptance/privacy risk surveys (Cazier et al., 2008; J. S. Smith et al., 2013), both of these papers used a theoretical RFID implementation example, which ensured a more accurate overall result.

Second, respondents were all based in the USA, so their attitude towards item-level RFID technologies may vary when compared to data from other countries. However, residents of non-westernized countries may react differently to new technology and in these situations, the research results should be used with care (Straub, Keil, & Brenner, 1997).

Third, a 3rd party company conducted the survey and therefore our respondents were limited to members of their online survey research panel, creating a potential bias as the panel may not be entirely reflective of the wider society. Also, there was a small donation to the charity of the respondents' choice made by the 3rd party.

There are several research opportunities suggested by the results. First, there was a higher response rate from females in the survey. While the greater response rate from women may be reflective of the dominant grocery-buying position that women have in the household, it may have implications for firms looking to implement and adopt RFID technology in the grocery sector. Future researchers could focus on how female acceptance of RFID technology would differ from men as gender influences acceptance (e.g., Venkatesh and Morris (2000)).

Second, it would be interesting to gain further insight into what input other members of the household had on the purchasing behavior of the primary household purchaser, for example, if another family member specified a certain brand over another and what the implications would there be if one had RFID and the other did not. Additionally, the in-store / after sales benefits/risks of a RFID product may be perceived differently by family members who are not the primary decision maker.

CONCLUSIONS

Consumer acceptance of RFID technology will be required to introduce the IoT in the FMCG around the globe. This research examined an FMCG home-market sample of consumers to understand perceived privacy risks and benefits of the introduction of RFID technology into FMCG. Therefore, this research expanded the conversation within academic literature beyond privacy risks to the consumer by expanding the investigation into consumers' perceived privacy risks using a quantitative survey within this paper. By investigating both in-store and after-sales categories in this research, insights emerge about how consumers may react to RFID implementation at an item-level within the FMCG industry and how the inclusion of consumer-focused benefits; both in-store and after-sale could negate consumers' perceived risks towards the technology. We find that consumers' concerns about risks are weighted more heavily to after-sales risks, suggesting that consumers would expect a level of risk while using item-level RFID within a store environment but believes that these can be sufficiently addressed. Therefore, acknowledging after-sales risks and developing a more comprehensive range of benefits for consumers will be required to overcome perceived potential risks. Also, this research should give a solid foundation for research into consumer acceptance of IoT appliances as they will have a similar privacy risk/perceived benefits balance. Based on this research, global FMCG firms will be better able to manage implementations of this type of RFID technology, by understanding consumer concerns and how to highlight consumer benefits, in a way that will enable them to manage better information and production flow around the globe.

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Appendix A. Survey questions (The Future of Grocery Shopping)

Section A.

We asked two questions to ensure the respondents belonged to our target population
1. How old are you? *Under 18, 18 to 25, 26 to 34, 36 to 44, 46 to 55, 56 to 65, Older than 65*
2. Are you the grocery purchasing decision maker for your household? *Yes, No*

We provided an overview scenario and instructions for completing the survey:

> *In the near future, a new Smart Technology will emerge allowing effortless wireless interaction between mobile phones and individual grocery items or items as a group. There are a number of ways in which to interact with the items, the most popular being a mobile phone app, which requires you to register your personal information and log in to be able to use it. This app needs to store information about your previous purchases, current grocery items at home and shopping patterns to work accurately. While answering the survey, pretend that you have access to this technology now. Read each statement carefully and select the option that you most identify with, from strongly agree to strongly disagree.*

Section B.

The following 24 questions were asked using a 5-point Likert-type scale to capture the responses. On this scale, the following descriptions were used:

1 = Strongly Agree
2 = Agree
3 =Neither Agree nor Disagree
4 = Disagree
5= Strongly Disagree

Survey questions	Likert-type scale				
	1	2	3	4	5
1. The smart technology would make it possible to take previous shopping lists and calculate the current cheapest grocery store to purchase the exact items again. This feature will benefit me.					
2. The smart technology could potentially place consumers in a shopper group or label them a type of buyer based on purchase history. I would consider this a potential risk.					
3. The smart technology would make it possible to scan products and keep a running total of a current shopping list. This feature will benefit me.					
4. The smart technology could allow stores to track your movements and buying patterns in a grocery environment. I would consider this a potential risk.					
5. The smart technology would enable discounts on items by scanning your mobile phone on in-store coupons. This feature will benefit me.					
6. The smart technology could allow a company to access your grocery purchase history for future targeted marketing. I would consider this a potential risk.					
7. The smart technology would make it possible to completely automate the shopping process based on previous sales data and a set budget limit. This feature will benefit me.					
8. The smart technology could make it possible for companies to collect demographics data (Gender, Age, Ethnicity, Annual salary and hometown). I would consider this a potential risk.					
9. The smart technology would make it possible to view the inventory of a pantry / kitchen, live via smartphone. This feature will benefit					
10. The smart technology could allow other people to scan grocery items and see where and when they were purchased and how much was paid. I would consider this a potential risk.					
11. The smart technology would make it possible to automatically generate shopping lists based on previous purchases and current pantry / fridge inventory. This feature will benefit me.					
12. The smart technology could suggest items that consumers may not want, need or want to be associated with. I would consider this a potential risk.					
13. This Smart Technology will save me money while grocery shopping.					
14. I am concerned that this Smart Technology may track my purchases.					
15. Using this Smart Technology will make grocery shopping more efficient.					
16. I am concerned that this Smart Technology may monitor where I have visited.					
17. Overall, this Smart Technology will be useful to me.					
18. I am concerned that this Smart Technology may track where I have visited					
19. I like the idea of using this Smart Technology.					
20. Using this Smart Technology will be positive.					
21. Using this Smart Technology is a good idea.					
22. I intend to use this Smart Technology when it is made available.					
23. I intend to use this Smart Technology when it is placed on items.					
24. I intend to use this Smart Technology frequently when it is available.					

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Table 1. Demographics Data

Demographic	Category	Percentage	[n=248]
Gender	Male	33.5%	83
	Female	66.5%	165
Age	18 to 25	0.8%	2
	26 to 35	12.1%	32
	36 to 45	20.5%	54
	46 to 55	31.1%	82
	56 to 65	35.6%	94
Education	Middle School - Grades 4 - 8	0.4%	1
	Completed some high school	2.0%	5
	High school graduate	25.8%	64
	Other post high school vocational training	4.8%	12
	Completed some college, but no degree	21.0%	52
	Associate Degree	12.5%	31
	College Degree (such as B.A., B.S.)	21.0%	52
	Completed some graduate, but no degree	1.2%	3
	Master degree	10.1%	25
	Doctorate degree	80.0%	2
	Prefer not to answer	40.0%	1
Household Income	Less than $9,999	4.4%	11
	$9,999 to $19,999	14.1%	35
	$20,000 to $29,999	10.5%	26
	$30,000 to $39,999	12.5%	31
	$40,000 to $49,999	8.9%	22
	$50,000 to $59,999	15,7%	39
	$60,000 to $69,999	8.9%	22
	$70,000 to $79,999	6.0%	15
	$80,000 to $89,999	4.0%	10
	$90,000 to $99,999	4.0%	10
	$100,000 to $124,999	3.2%	8
	$125,000 to $149,999	3.6%	9
	$150,000 to $174,999	0.8%	2
	$175,000 to $199,999	0.4%	1
	Over $200,000	0.4%	1
	Prefer not to answer	2.4%	6

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Table 2. Household Incomes – Sample vs. 2011 US Census

Household Income	Survey	2011 US Census
Less than $9,999	4.4%	7.6%
$9,999 to $19,999	14.1%	11.6%
$20,000 to $29,999	10.5%	11.3%
$30,000 to $39,999	12.5%	10.6%
$40,000 to $49,999	8.9%	8.9%
$50,000 to $59,999	15,7%	7.8%
$60,000 to $69,999	8.9%	6.8%
$70,000 to $79,999	6.0%	5.8%
$80,000 to $89,999	4.0%	4.6%
$90,000 to $99,999	4.0%	4.0%
$100,000 to $124,999	3.2%	7.5%
$125,000 to $149,999	3.6%	4.4%
$150,000 to $174,999	0.8%	3.2%
$175,000 to $199,999	0.4%	1.7%
Over $200,000	0.4%	4.2%
Prefer not to answer	2.4%	N/a

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Table 3. Internal Consistency Reliability Results

Construct	Composite Reliability
After Sales Benefits (ASB)	0.878
After Sales Risks (ASR)	0.875
In-store Benefits (ISB)	0.892
In-store Risks (ISR)	0.856
Intention to Use (IOU)	0.977
Perceived Benefits (PB)	0.929
Perceived Risks (PR)	0.941
Technology Acceptance (TA)	0.965

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Table 4. Convergent Validity Results

Construct	AVE
In-store Benefits (ISB)	0.733
After Sales Benefits (ASB)	0.700
Perceived Benefits (PB)	0.814
In-store Risks (ISR)	0.665
After Sales Risks (ASR)	0.700
Perceived Risks (PR)	0.842
Technology Acceptance (TA)	0.901
Intention to Use (IOU)	0.933

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Table 5. Discriminant Validity Results. The shaded diagonal values are the square root of the AVE extracted for each construct; in each case these values exceed the highest correlation with any other construct to fulfil the Fornell-Larcker criterion.

	After-sales Benefits	After-sales Risks	In-store Benefits	In-store Risks	Intention to Use	Perceived Benefits	Perceived Risks	Technology Acceptance
After Sales Benefits (ASB)	0.840							
After Sales Risks (ASR)	-0.315	0.837						
In-store Benefits (ISB)	0.699	-0.237	0.856					
In-store Risks (ISR)	-0.285	0.800	-0.217	0.815				
Intention to Use (IOU)	0.684	-0.428	0.672	-0.336	0.966			
Perceived Benefits (PB)	0.748	-0.364	0.791	-0.321	0.828	0.902		
Perceived Risks (PR)	-0.437	0.663	-0.292	0.615	-0.543	-0.455	0.917	
Technology Acceptance (TA)	0.751	-0.452	0.693	-0.389	0.878	0.850	-0.593	0.949

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Table 6. R^2 Value for the Constructs

Construct	**R^2 Value**
Perceived Benefits (PB)	0.698
Perceived Risks (PR)	0.456
Technology Acceptance (TA)	0.775
Intention of Use (IOU)	0.769