Exploring the inherent benefits of RFID and automated self-serve checkouts in a B2C environment

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Abstract: Automated identification services such as RFID and self-serve checkouts that require many different technological components in order to successfully operate and be accepted in a B2C (Business-to-Customer) environment. In theory, using self-checkouts as a proxy for RFID applications, allows for an investigation of potential consumers' acceptance of self-service technology to be determined when applied to a retail environment. In terms of factor analysis results, three independent constructs were found from the interval Likert-type and binary discrete variables from the questionnaire data. The three major constructs that were generated from the factor loadings, renamed based on the variables that loaded with loadings equal to greater than 0.5, included: positive experience, privacy and demographics, and acceptability of technology. The independent constructs of positive experience ($t = 6.296$, $p = 0.000$) and acceptability of technology ($t = -2.478$, $p = 0.016$) were the most important factors in predicting the frequency of use of such automated technologies in a retail grocery setting.

Keywords: adoption of technology; automatic identification; Business-to-Customer (B2C); Customer Relationship Management (CRM); Radio Frequency Identification (RFID); self-checkout; strategy.

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1 Introduction

Radio Frequency Identification (RFID) technology is being used as a new approach to deal with traditional bar-coding system for business applications and to resolve many logistical obstacles that companies face. RFID essentially captures data from an object without physical contact. This paper discusses the implementation process which includes the facilitation of this technology, cost and benefits, and a few case studies of companies that utilise this technology. Current advances in RFID, followed by some of major disadvantages of RFID, which includes cost, training, product labels and supplies, and privacy infringements (Pottie, 2004) will be discussed. Just like any technology, RFID has advantages and disadvantages, but ultimately, it will benefit both the retailer and consumer by providing an innovative way to handle retail merchandising. Lastly, an empirical study of reactions is done to the widespread use of such technology and Customer Relationship Management (CRM) implications at the Business-to-Customer (B2C) level via an investigation of customers concerning self-checkouts experiences in retail grocery outlets in the Pittsburgh, PA metropolitan area. It is a basic assumption of the present study that the implementation of RFID should have a positive impact on CRM applications, as well as improved Supply Chain Management (SCM).

1.1 Basic concepts of RFID

RFID and automated identification systems have recently been popularised in the press, both from positive and negative perspectives. Automated identification systems and its related technology have great potential to enhance business activities and customer relations (Albrecht, 2002). Therefore, it is important that both business leaders and customers to understand this technology. RFID and related automated identification systems deal with electronic tagging technology that allows an object, place, or person to be automatically identified at a distance, without a direct line-of-sight, using an electromagnetic challenge/response exchange (Want, 2004). Kinsella (2003) describes RFID as a straightforward technology that permits machines to share information wirelessly. Although the idea behind the technology is relatively simple, it is a system comprised of many parts, including tags attached to products that send information, readers to receive the information sent by the tag, and software to collect and properly store the information. Both the tag and the reader are attached to an antenna, which transmits and receives the data between the tag and the reader. Once the tag sends its information to the reader, the reader's job is to send it along to the appropriate computerised device (Boyle, 2002).

RFID and related automatic identification systems can be also be more complex, with the inclusion of additional components such as stations to programme, the tags, and sorting equipment. Security can also be implemented on the data and stored on the tags through the use of technologies such as security gates or a security bit (Security friend and foe, 2003; Smith and Offodile, 2002; Smith and Rupp, 2002a–b*)*. Enhanced security can be provided through the use of physical tamper-detection methods such as an attached wire to the tag. The package is broken once it is opened (Want, 2004). The function of an RFID system is basic in definition but the components themselves are not. There are several aspects needed to understand this system, *e.g.*, varied parts of the RFID system, different types of tags and how they operate, details of readers, and the ways that tags and readers actually communicate with each other.

The tags can fall into one of several categories, *e.g.*, active, passive, or semi-passive. Active tags are equipped with a battery and they send out a signal to the reader. Passive tags are much smaller and they have no source of energy. Instead, they rely on an initialisation signal from the reader to power the tag's antenna, which then sends the information back to the reader. Finally, semi-passive tags are a combination of the other two types, in that they have a battery to handle the operation of the on-chip circuitry, but rely on a signal to handle communication with the reader.

Tags should ideally have the ability to read and write data (a read-write capable tag) in order for them to achieve their full usefulness. There are currently two common types: inductively coupled RFID tags and capacitive-coupled tags with each of these consists of three parts. The three comprising parts for an inductively coupled tag are a silicon microprocessor, a metal coil, and an encapsulating material. The size of the microprocessor can vary depending on the function of the tag and is usually arranged in a circular formation with the metal coil constructed from aluminum or copper wiring. A magnetic field put out by a reader is the initial power source for an inductive RFID tag.

The tag reader is the nest major component in the RFID system. Currently, individual reader unites are expensive ($1000/each), and a particular reader is capable of receiving transmissions on only one frequency. Specifications are being developed to create an agile reader that would be capable of reading more than one frequency. The end goal is to produce these agile readers for around $100/reader in bulk.[1] Another issue to consider regarding readers is error detection and correction to ensure that the information sent by the tag has been correctly received by the reader. There are a few available technologies to implement such error-checking. A Cyclical-Redundancy-Check (CRC) or other such checksum code can be used to ascertain that the reader has in fact correctly received the tag's information. There are also many Error Correction Code (ECC) methods that can be used to fix bad bits. This would reduce the need for rescanning (Dipert, 2004).

As previously mentioned, readers and tags communicate utilising a radio frequency, but there is a lack of a universal frequency standard in use. Instead, there are several ranges of frequencies in use by RDIF. Tags are generally divided into discreet categories depending on the range that they use. Low frequency tags operate from 125 and 134 kilohertz, high frequency tags are on an international standard of 13.56 megahertz, UHF tags communicate from 868 to 956 megahertz, and lastly microwave tags run at 2.45 gigahertz. Signal corruptions, and thus data errors, are very likely to occur despite the wide variety of frequencies available due to the large amounts of both RFID tags and other technologies that use radio frequencies. There are several available methods to reduce this occurrence. Amplitude key shifting, frequency modulation, pulse-width modulation, and phase modulation are all methods that can be used. There are also some schemes for RFID tags in particular that can reduce the likelihood of two tags transmitting data at the same time. These include: Time-Division-Multiple-Sccess (TDMA) methods, phase jitter modulation, frequency-and-time-division-multiple-access (FTDMA), and eight-channel frequency hopping for anti-collision interference avoidance (Dipert, 2004).

1.2 Standardisation efforts

There is currently no universal standard for RFID and related automatic identification systems. Thus, EPC Global has been established to create such a standard (Traiman, 2001). There are also a few miscellaneous technical problems with RFID that will need to be worked out in the future. Concerns include what EPC Global is and how it proposes to standardise RFID, as well as explain the remaining technical problems. Since RFID is still a maturing technology, there are still a couple of technical issues to resolve. The reader has a very difficult time retrieving the information when the tag is positioned perpendicular to the reader. The only feasible solution is to strategically place readers, covering an area as wide as possible. Coordination of readers will be another problem since their current design cannot operate in the presence of another reader. Multiple proprietary data formats are still another issue that needs to be fixed. If one standard format was decided upon, then information could be more easily shared amongst independent organisations (Want, 2004).

EPC Global is a joint-venture organisation that includes HP, Gillette, Wal-Mart, and the Massachusetts Institute of Technology as members. Its goal is to create a standard for RFID technology so that it may eventually be more easily implemented (Holland, 2004). The key component in standardising RFID will be the use of its Electronic Product Code (EPC). This is a standardised format code that will contain up to 96 bits of information. The tags themselves will not be regulated since EPC will be placed on whatever tag an organisation wishes to use. The tag reader will then use a network connection (internet) and EPC's Savant network programme to store and track the data collected by the tags (Traiman, 2001). Actual product information will be stored in a new file format called Physical Markup Language (PML), which will allow easier organisation of product data.

1.3 Implementation of RFID-related technology

There are many considerations and obstacles that retailers must be able to overcome before they can successfully implement RFID into the supply chain. A retailer implementing RFID technology will ultimately be unsuccessful in implementing this technology if they do not analyse their business processes, do not analyse the effect that RFID and related automatic identification systems will have on their organisations current operations, and fail to plan for RFID implementation. While RFID has the potential to increase the effectiveness and efficiency of a retailer's internal and external operation (supply chain), RFID technology is incapable of accomplishing these tasks by itself. RFID must be implemented within the retail store and its supply chain partners, along with being integrated in other business applications.

1.3.1 Benefits within the supply chain

Retailers must look at their internal operations and decide if RFID would be suitable for their organisation before implementation. Management within the organisation must determine whether the derived benefits within the supply chain are great enough to offset the potential risks and problems they will encounter, specifically costs (RFID: good or bad, 2004). Some obvious benefits do exist while some are difficult to determine because no retailer has yet to successfully implement RFID on a large scale. "It can enable the storage and relay more item-level data associated with specific product's lifecycle. It can provide item level inventory visibility in real time with higher accuracy (Kinsella and Elliot, 2005,p.33). Hence, RFID and related automated identification technologies can dramatically reduce manual efforts associated with material handling and management. Essentially, RFID allows retailers to more effectively monitor and control the products within the supply chain. This can potentially result in an increase in productivity and a decrease in cost.

The reduction of theft within the supply chain is another result of RFID implementation. This is an enormous expenditure to most retailers, *e.g.*, Woolworth's estimate that 55% of all product theft occurs in the supply chain prior to goods reaching the retail store (Kinsella and Elliot, 2005). This may be enough justification for RFID implementation, depending on the degree that supply chain theft costs an individual retailer. However, it depends on decision makers within the organisation to determine whether the benefits of RFID outweigh the risks, such as cost, and risks yet to be uncovered, which may or may not be substantial.

1.3.2 Cooperation among supply chain partners

Retailers must also consider their relationship and the degree of cooperation they will receive from their supply chain partners. The retailers, suppliers, and manufacturers within the supply chain must install RFID for successful implementation. This could be a daunting task because while retailers recognise benefits early, suppliers and manufacturers may not see immediate results. This problem is further escalated when manufacturers and suppliers are required to absorb most of the costs.[2] This could hinder manufacturers and suppliers from adopting this technology in the early stages of RFID implementation. However, as more retailers implement RFID within their stores, the greater compliance they will see with manufacturers and suppliers.

1.3.3 Changes in technology

The change in the technology that is needed for RFID's success is one of the most important areas where retailers to be aware of. It is also important to try to adapt the existing technology to accommodate RFID in order to prevent a complete overhaul while replacement of current technology in an organisation is necessary for deploying RFID, (Barthiaume, 2004; Smith and Offodile, 2002). Both employees and management may meet a complete overhaul of the current technology with more resistance. New technology requires employees to put forth more time and effort to learn a new system that they may or may not see as beneficial. Employees and management may be more receptive to new technology if it is combined with existing technology that is comfortable to use. Implementing technology will need to be purchased for successful implementation since continuous flow of information is provided by RFID and related automatic identification systems. Traditionally, technology has had to handle receiving data in batches a few times a day while RFID provides ongoing flow information. Technology in today's retail store, lacks the capability to handle this continuous flow of information.

1.3.4 Data management

The business processes and the functions performed by employees and management will change with the implementation of RFID. The continuous flow of information by RFID for retailers will change the way that managers and employees manage data. Employees within the retail industry must be accustomed to handle large data, and process this data in a short time. Retailers must make provisions to collect and filter data coming from multiple sources, manipulate and evaluate the data, and then forward the refined data to a database management system in order to accommodate these changes (Boone, 2004). This change in data management will require many retailers to restructure the business processes within their organisation; this not only includes the functions performed by the employees and management, but also the technology used by the retailer.

1.3.5 Changes in business processes

While RFID and related automatic identification technologies are the main driving force behind the benefits derived from implementation, it cannot reach its full potential without changes within the organisation and its processes:

> "Adapt business processes to take advantage of new supply chain data. Case level tracking of merchandise will offer new opportunities for inventory management, product tracing and recall management, but it may require substantial change to current business processes and perhaps even to enterprise-wide platforms." (Praskey, 2004,p.60)

Retailers must recognise that technology is only as good as the people who use it. Therefore, it is essential that retailers educate their entire organisation, not just management, on how RFID works, the benefits that can be derived from, and the changes that it will create (Barthiaume, 2004). Only when the employees recognise the benefits RFID will create for them and the organisation, will they be openly receptive to the changes that RFID will bring about.

Employee receptiveness in the implementation of RFID is essential in its success because their jobs that will be affected the most by RFID. This includes every individual within the organisation, not just those directly involved with RFID. The greater an individual's job in the organisation changes with the adoption of RFID, the more likely these individuals will resist the change. Thus, the end result will not be able to fully reap the benefits that RFID is capable of delivering for the organisation. It is essential that the retailer should make the transition from barcodes to RFID as painless as possible for their employees. This involves not only educating the employees, as previously discussed, but also not completely changing the environment that the employees have become accustomed to and comfortable working in.

1.3.6 Use of barcodes

Retailers must also recognise that while RFID has immense benefits over the traditional barcodes, barcodes will not be rendered obsolete. One of the biggest reasons for this is because barcodes will always be less expensive than RFID and related automatic identification systems' implementation no matter how far the costs for RFID decrease (Kevan, 2004). Retailers in today's competitive environment are looking for any means necessary to keep costs down. Companies can no longer afford to take unnecessary risks, especially if they do not see any benefits being derived from RFID towards their operation. This will require many manufacturers and suppliers to invest in both barcodes and RFID in order to stay competitive. "Unless companies pervasively use a technology across the supply chain, they are going to come across pockets where companies are not using RFID, and they're still leveraging bar coding and scanners" (Kevan, 2004,p.27). This could result in a loss of profit and a great deal of distress among supply chain partners if they were to install RFID while entirely disregarding barcodes. Supply chain partners must be aware of the current technology used throughout the supply chain when implementing RFID. This may require companies to continue using barcodes while RFID is slowly being adopted and deployed throughout the supply chain and the retail industry. While RFID is a relatively new technology in the way it is used, problems associated with the technology and the ways they can be solved are still unknown. Companies must be able to operate and incur the costs associated with reading and operating both barcodes and RFID until adoption of RFID and related automatic identification systems becomes universal.

1.4 Selecting a solutions provider

Once a retailer analyses their business and determines the effects of RFID on its operations, retailers must begin planning for implementation. The majority of retailers lack the knowledge, skill, and experience that is required to implement RFID within the supply chain. They may require the services of a solutions provider in order to assist retailers in RFID and related automatic identification systems implementation. Retailers must be cautious in selecting a solutions provider, and select the individual or company that provides experience, has an understanding of a retailers business, and one that will best be able to give the retailer the greatest return on investment (Boone, 2004). This is imperative in an organisation's success, "Ideally, the solution provider also will be able to provide a holistic approach that includes the hardware, software, middleware, and the integration and implementation services required to implement effectively and efficiently" (Barthiaume, 2004,p.44). While the retailer is the one who makes the investment in the technology, it is the solutions provider that ensures that the technology complements one another in achieving the retailer's objectives. As important as it is to select the right solutions provider, it is just as detrimental to an organisation to select the wrong company or individual. There are many different aspects and pieces of technology that encompass RFID, and selecting a solutions provider with limited knowledge and/or experience may result in the unsuccessful implementation of RFID and related automatic identification systems. This will not only cause a company great amount of distress, but also an increase in costs and a loss of time.

1.4.1 Data synchronisation

One area that is critical to the success of RFID, and has yet to be resolved, is that data must be synchronised across supply chain partners. Communicating and exchanging information among partners is vital in the success of the supply chain. This may be currently difficult for many retailers and manufacturers because there are no standards regarding RFID. Retailers, manufacturers, and suppliers need to further develop and promote standards through the early development of RFID implementation. Many have began doing so through adopting UCCs (Uniform Code Council) Global Data Synchronisation (Barthiaume, 2004). Developing standards for RFID implementation will not only prevent problems in the early deployment stages, but also in the long-term use of RFID and related automatic identification systems. "To effectively use RFID as a supply chain accelerator, retailers and CPG companies also must be able to exchange data in a common format with universal product descriptions" (Barthiaume, 2004,p.44). While retailers, manufacturers, and suppliers realise the importance of data synchronisation, rectifying this problem is a challenge. There are a variety of different tags and frequencies that a retailer can choose from in order to meet their organisational needs (Samwel, 2004). The technology used by one retailer may not be the same technology used by another retailer. While this poses little problems for the retailer, the manufacturer and suppliers of these retailers are caught in a dilemma. They either have to lose the business of the retailers who do not comply with their current RFID technology, or have to incur the costs of implementing several different RFID and related automatic identification systems.

1.4.2 Planning the budget

Retailers must prepare a budget before they implement RFID into their store and throughout the B2C value chain. Retailers must be aware of the necessary financial and human capital for successful implementation. There are significant costs associated with RFID implementation, such as the cost of the technology (tags and readers), restructuring of the store, the software, and the people needed to carry out the implementation.

> "Evaluating the costs associated with the effort relative to the anticipated benefits, and monitoring the extent to which those costs change due to unforeseen factors will enable retailers to effectively gauge the success of the implementation."[3]

A lack of consideration of these costs could potentially produce an ineffective and/or inefficient deployment of RFID. This can ultimately lead to companies straying away from their original goals of full implementation, or attempting cut some corners which may lead to a less than optimal implementation of RFID. Just as important as having the necessary financial capital to back implementation, retailers must also have the right employees. This involves employees who are knowledgeable and capable of operating the technology to utilise RFID and automated identification systems' full benefits. This is left up to the manager to educate their employees on maximising the use of technology. When retailers fail to consider the necessary expenditures when implementing RFID, the greater the chance there will be for the organisation not being able to reach their implementation and organisational goals.

1.4.3 RFID testing

Many retailers, before implementing RFID into their actual operations, want to know about the potential benefits and risks associated with this technology. However, they are unable to implement RFID within their actual operations and be able to absorb the consequences if it was to be unsuccessful. Retailers can use simulated tests to better understand the potential benefits and risks that RFID will bring a retailer and their supply chain. These tests would be conducted in a laboratory where an attempt is made to simulate the conditions in the supply chain. While this may give retailers and their supply chain partners an indication on the benefits and risks resulting from RFID, nothing can account for real world simulation (Barthiaume, 2004). As previously mentioned, RFID is still in its pioneering stage and many of the problems associated with its implementations are unknown. These problems may vary with each retailer and supply chain, so trying to conduct research under a controlled environment and get usable results may prove difficult. Implementing RFID on a trial basis within B2C value chains may prove costly, but those companies that are able to successfully do so will not only have a competitive advantage, but also set a foundation for others to follow.

1.4.4 RFID pilots

There are two different approaches that retailers are capable of utilising if a company decides to implement RFID within their supply chain. This may often depend on management company's handling of both financial and personal wise and the individual needs of the retailer. Some retailers may decide to implement RFID and automatic identification systems on a full scale. This would require all the products and areas within the B2C environment to be tagged and integrated within the supply chain (Smith and Offodile, 2002). This method may not only provide immediate return on investment but also brings about greater risk for a company. Full implementation would be more costly and would take much more cooperation from the supply chain and the employees of the retailer.

A less drastic approach to full-scale implementation is a small-scale pilot implementation. This involves certain items and store areas that will give the greatest insight on how implementation would work on a large scale. Based on the success of this small-scale implementation, retailers may decide to gradually include other products and store areas in RFID and automated identification protocols implementation. This approach may bring less risk and avoid a complete overhaul of the organisational structure, but it will not recognise the benefits as quickly or may reduce the significance of those benefits.

1.4.5 Merchandise inclusion

Companies must select the right type of merchandise during the pilot implementation of RFID, specifically on a small-scale. The selected items should provide the greatest benefit with the least amount of risk. The products that best suit this criterion are items that are vendor managed such as CD's, books, and DVDs. Retailers should also include expensive items that have traditionally been susceptible to theft within the retail store and the supply chain. It is through these types of items that retailers will be able to recognise if RFID adds any significant benefits to their operation. The perceived benefits of RFID include better inventory management and reduced theft. Selecting merchandise that is neither readily stocked by vendors, nor has high shrinkage rates would make it much more difficult for companies to compare the results of RFID over traditional barcodes and see significant benefits.

1.5 Physical structure of the retailer

The physical structure of the retailer, besides the business processes and technology, will need to be changed and adapted to RFID. The environment and placement of RFID tags are essential for the readers to read the data successfully. This will require changing the store shelves and fixtures for successful reads:

> "Redefining original stores' planograms and required fixturing should be undertaken in a way that maintains the identity of the stores' visual merchandising, while at the same time makes the addition of RFID technology virtually transparent to the consumer."[2]

Failure to do this will not only make the consumer less comfortable when shopping in a B2C environment, but it would also require employees to learn a new store layout.

Better inventory management for the retailer will be achieved with the installation of RFID, comes. This will allow retailers to carry less of a product, and ultimately free up space that could be utilised for other functions. “Proper planning for, and utilisation of, excess selling space will likely translate directly to the bottom line, as additional merchandise will be available for sale without the costly requirement of store redesign and remodels.”[2] Increased store space is one benefit of RFID implementation for retailers; however, it only becomes a benefit if retailers are able to use this space productively. An area that was once used to house inventory brings no benefits or profitability to a retailer if it becomes an empty space.

RFID may not be for every retailer or supply chain as long as costs remain high; it is up to management to determine whether the benefits of RFID will contribute to greater profitability of the company, and if so how do they go about implementing RFID. Implementation of RFID cannot be done overnight because there are many involved aspects in successful implementation within the retail store and the supply chain. Retailers must consider the needed technology, the affected business processes, and other parts of the organisation that will need to be changed or adjusted to implement RFID successfully.

1.5.1 Retailers and RFID

RFID has become the next technology that may be of large-scale use in the retail environment. RFID tags are meant to help reduce theft, better locate items, increase customer service, match supplies for demands of products and speed distribution. Unlike barcodes which must be passed in front of a scanner, a device up to 20 feet away can read RFID tags remotely. This flexibility offers retailers many new ways to increase CRM. They can also use RFID to expedite returns, manage warranties, and deliver after sales support.

Although RFID has many benefits for retailers, there are concerns as well, *e.g.*, the possibility of increased liability to a retailer. A business that has the potential to advise customers of a product recall can potentially be held responsible if they fail to notify consumers. This opens the door for lawsuits which could cause insurance rates to rise. There are also costs to be considered, specifically the current costliness of the tags. Lastly, RFID technology has tracking capability after a sale is completed. Many consumers who are aware of such devices are not always keen on the idea of being continually tracked. This aversion to the tracking could cause a loss in market share.

1.5.2 Current laws

At least three states have introduced legislative bills to limit the use of RFID and related automatic identification systems. Lawmakers in California have introduced a bill to address consumer privacy concerns related to the commercial use of radio frequency technology (Alorie, 2004). US Senate Bill 1834 would apply to any business or state government agency using radio frequency identification systems to track merchandise or people. The bill proposes that business and agencies should be required to notify people that they are using a RFID system that can track and collect information about them. It would also require consumers to give consent before businesses or agencies could track and collect information about them via RFID (Alorie, 2004). In addition, the legislation requires retailers to destroy RFID tags on merchandise before consumers leave the store with it.

In most cases, existing privacy laws cover the use of data collected by RFID systems. The Federal Trade Commission (FTC) has taken an interest in the RFID and related automatic identification systems and is currently providing input to its standardisation and implementation. RFID tags do not really offer more data than the current loyalty (or customer tracking) cards and barcodes already in use. Stores can already link a particular customer to the products they buy by using bar coding. An RFID tag, from a consumer standpoint, merely streamlines the method whereby stores process their customers. The use of RFID and related automatic identification systems may become a greater asset if ethically used by businesses.

1.5.3 Benefits to consumers

There are many potential benefits of RFID and related automatic identification systems for consumers. It can help secure the food supply, provide protection from disease, enforce security and provide timesaving efficiency to consumers, aside from the improved efficiencies of the retailer. Retailers, restaurants, and government agencies are currently employing the technology in many ways to help provide these safeguards. First, consider what per-product RFID does to the checkout line. The consumer could simply roll the cart through a set of RFID readers, instead of waiting for a checkout clerk to swipe each product across a barcode reader by hand. The total would appear on the display almost immediately. If a consumer pays by credit card, then the interaction with a human being would be minimal. At best, the checkout person would be responsible for comparing your signature to the one on the back of your card. The entire process could take under a minute! Condensed checkout times ultimately provide better service to the consumer.

Another example is a grocery store chain using the tags to track the expiration date of meat. The store can alert buyers of any contaminated meat through the tracking of RFID. This benefit can save lives and potentially prevent outbreaks, *e.g.*, recent Mad Cow disease scare. RFID tags have enabled retailers to have more control over their supply chain. RFID technology is used to track in-store merchandise as well. Greater efficiency in the supply chain will reduce costs and improve efficiencies. The fully stocked shelves will offer a consumer the guarantee that merchandise they seek will be available when needed.

Theft in a retail store can reach exuberant numbers. Shortages created by theft often result in lost sales because consumers cannot buy what is not on the shelf. In addition, it would make it much more difficult to sell a stolen product since it could be more easily identified due to each product's unique ID. The theft can be significantly reduced in using RFID technology. These savings will likely be realised as better pricing for consumers. Many toll roads use RFID technology in the form of ES Pass radio transponders attached to windshields. A person simply drives through a reader and the activity is immediately recorded to their account. This convenience reduces traffic and drives time as well as labour costs.

1.6 Consumers and privacy

While business people and industry leaders applaud the use of RFID technology in retailing, many concerns are raised as far as consumer privacy is concerned. RFID is a potentially dangerous technology because RFID chips can be embedded into products and clothing and secretly read. Consumer advocacy groups, such as Consumers Against Supermarket Privacy Invasion and Numbering (CASPIAN), legal experts and concerned consumers have raised questions on what could happen if RFID devices were used to track and monitor products after consumers purchase them instead of being used strictly to track goods through a supply chain. Privacy advocates have legitimate concerns regarding the threat to privacy that RFID technology presents.

RFID is typically used to track objects. Tracking permits retailers to slim inventory levels and reduce theft, which may reach $50 billion per year.[4] Thus, tracking is performed out of economic consideration and not the invasion of privacy. Yet, the potential abuse in tracking objects, therefore people, has given rise to spirited debate regarding RFID and automatic identification technologies. Although the concern may be real, others in the industry do not seem to be a threat. According to Cline (2004):

> "The privacy scare surrounding radio frequency identification tags is greatly overblown. No company or government agency will be secretly scanning your house to find out what products you've purchased, because there is no feasible way to do so." (p.44)

It is surmised that the actual invasion of privacy, while possible, is not probable to occur. The costs related to tracking all its citizens would be astronomical and technologically infeasible. Companies that are pushing RFID technology into our daily lives however; need to adopt some rules of conduct. There should be an absolute ban on hidden tags and covert readers. Tags should be deactivated when purchased by consumers. In essence, this technology should never be used to secretly unmask the identity of those who wish to remain anonymous.

1.7 Steps to responsible implementation

A retailer should follow guidelines to protect consumers' privacy and themselves. The first concern should plan to develop a privacy framework that organisations can use to comply with emerging privacy laws and policies. From an ethical standpoint, RFID automatic identification-related technologies' usage should be revealed to consumers. The implementation of RFID technology could be an easier transition by adopting an open door communication between the retailer and consumers.

1.7.1 Cost considerations

As previously mentioned, cost is a factor that may hinder the widespread utilisation of radio identification tags. Multiple expenses are inevitable in implementing this technology. RFID tags are used on shipments rather than individual items to defray some of the costs at its current stage of maturity. It is a long-term investment and short-term benefits hardly exist. Those who are willing to assume the financial risk of investing a large sum into RFID will eventually have a large competitive advantage over those who did not invest and explore the possibilities of radio frequency ID tags.

There are numerous costs associated with the execution of RFID. These expenses include tags, readers, printers, middleware, consulting, research and development, implementation, training, changing and training management, service-provider fees, and additional labour (*i.e.*, tags range in price from $.55 to $55 (McClenahen and Purdum, 2004)). As the quantity of tags increases, the price decreases. Ordered per million, the price can be as little as $0.20/tag (Wood, 2004). The readers needed to obtain the information from the tags range from $1000 to several thousand dollars depending on the size of scale needed to support the system. Middleware (the software that runs the operation) costs vary from $25,000 to several thousand dollars (Shutzberg, 2004). Many expenses will be incurred – everything from the equipment to the management educating employees – without a real sense of what the benefits can be.

1.7.2 High price hinders profits

The price of RFID is still relatively high since it is still in its infancy in the retail market. Retailers are opting to tag selected items to compensate and still receive the benefits. The included items are those that are usually high in price and prone to theft. Such items may include watches, DVDs, and CDs (Brandel, 2003). This selective system is sufficient until the price of a tag is reduced to $0.10/tag or less, given the limited resources designated to RFID at this point in time (Brandel, 2003). It is essential that the price of the tags is as discounted as possible because the tag on the product is an additional cost to the store. As with all technologies, the price significantly drops as time passes. It is predicted that by 2006, tags will cost $0.05/piece (Brandel, 2003). However, some disagree with that optimistic prediction. P&G CIO Steve David believes that it will not be until 2011 that tags will be $0.01 or $0.02 (Murphy, 2004). Even though the tags may cost pennies, the other costs previously mentioned, such as additional equipment, implementation, and consulting, will remain relatively high.

1.7.3 Price problems

There are several issues that arise when considering the cost of implementing RFID. Currently, tags are being used for pallets of items. They are not attached to cartons, as it would drastically raise the cost for the business. Second, the price of the tags depends on the innovation to create tags at a reduced cost. The semiconductor industry cannot create innovation fast enough to construct tags that companies would be willing to purchase for pennies on the dollar (Wood, 2004). In addition, as previously stated, the price of the RFID tags decreases as the ordered quantity increases. The problem lies in the fact that at its current stage, any one company does not need millions of tags. Very few are or have begun to demonstrate any interest in RFID. Those who have are only in the testing process. They do not have a need for millions of tags. With the combination of little innovation to reduce costs and a small quantity of tags needed, the price remains high for tags.

1.7.4 Intangible benefits

Businesses will reap benefits in labour efficiencies and reduced theft as businesses invest their effort and money into RFID. Wal-Mart, a forerunner in utilising RFID tags on merchandise, expects a 10%–20% improvement in labour efficiencies (Brandel, 2003). This will indirectly save them money. RFID and related automatic identification systems will aid in control of theft. The tags can sound if they are taken and not deactivated. This can help reduce employee theft in back rooms and theft on the sales floor. Jeff Wacker, an EDS Fellow and futurist at Electronic Data Systems Corp states that nearly 30% of capital budgets are for stolen (or lost) items (McClenahen and Purdum, 2004). Employees cannot perform their duties when items are stolen, and this in turn affects the operational budget. RFID can allow for better control of merchandise and help the business operate efficiently.

1.7.5 Early adopters pay high price

The pioneers of RFID in the retail environment will incur enormous costs because they will spend additional funds for the research and development of tags. First time mistakes will inevitably be made. More retailers will utilise the new system as the technology improves. Until then, it is the responsibility of those who are willing to cope with the obstacles that lie ahead of them. It has been estimated that companies who are willing to comply with retailers that require the tags will spend $9 to 25 million just to comply with the bare minimum requirements (Shutzberg, 2004). Wal-Mart has required its top 100 manufacturers to be RFID compliant by January 2005. A manufacturer will invest nearly $13–23 million to satisfy those demands (Wood, 2004). ROI will come from being in position to take advantage of the technology when it comes into widespread use (Beaver street fisheries stands to benefit from Wal-Mart's RFID mandate, 2004). Manufacturers will realise that the long-term benefits are more important than short-term costs.

1.7.6 Inventory control

RFID has numerous possibilities for improving the control of inventory. Having a better tracking system for items can save a retailer millions of dollars since theft and stock outs can be completely eliminated. The benefits of RFID are both tangible and intangible. Inventory, by the nature of the operations of RFID, is constantly monitored – where it goes, how long it takes to get there, and what needs to go where. This is of great benefit to retailers. Tracking inventory is often a difficult task especially on small items that are relatively easy to steal. Unfortunately, nearly 2% of revenue is lost due to inventory shrinkage (Kinsella, 2003). Product sensors act as anti-theft devices and are shut off at the point of sale; they react like current security devices (Thomas, 2003). Counterfeiting is also a large concern for many retailers. Companies believe the cost of counterfeit products is even greater than the losses incurred for shrinkage (Kinsella, 2003). If RFID technology can reduce these two important factors, then the cost of implementing the system can be absorbed (Kinsella, 2003).

Another benefit of RFID is the reduction of out-of-stock inventory. According to the Grocery Manufacturers of America, 4% of sales are lost due to insufficient inventory when customers desire them. On average, conditions like this occur 8.3% of the time according to Bednarz *et al.* (2003). This system can alert managers when items are sold; having passed through the point of purchase, indicating that the inventory on the shelves has reduced and needs to be stocked. This greatly decreases a number of out-of-stock items. The end result is more efficient replenishments (Kinsella, 2003). Items will be available to customers and more products will be on the shelves at all times (Dunn, 2004). This will help improve customer loyalty and CRM implementation efforts

(Smith, 2002; 2004). As previously mentioned, customers will potentially remain faithful to the retailer who makes their life the easiest, without having to shop store-to-store to collect the items they need.

Fewer resources are needed to sustain RFID and related automatic identification systems. By better controlling the inventory, fewer items will need to be replaced on the basis that they were stolen or misplaced (Dunn, 2004). Employees will feel the effects of better control because their job responsibilities will be altered. They will be able to put forth effort on different tasks instead of constantly replenishing the inventory. RFID tags will also aid management in controlling the inventory from being stolen by employees. Radio frequency readers would make it more difficult for employees to steal in back (employee only) and store rooms because it can be installed anywhere. The likeliness that they are caught increases, but the chance that they would attempt to steal knowing such a precise system was implemented would deter them from trying. Radio frequency identification tags in the retail industry can be very beneficial. An increase of in-stock items aids both the store and the products. The constant visibility of the brand name helps reinforce the product name and customers will continue to purchase items in the category and possibly alternate their behaviour in selecting new brands.

1.8 Customer service

RFID tags will give an opportunity to enhance the relationship between retailer and customer. The retailer will be able to offer better services; working to reach the ultimate goal of gaining customer loyalty. Customers will lose some of the personal contact as they surrender to automated services. The consequences of this are unknown, but feelings towards other automated services (*i.e.*, self-checkout) are key indicators for predicting the customers' reactions to new technology.

1.8.1 Benefits to the customer

Implementing RFID tags in the industry will improve the services that customers receive by making their shopping experience more pleasurable (Belkin, 2004). It is suggested that RFID scanners will be available for customers. Customers would be able to retrieve valuable information like common allergens that food products may contain or new recipe ideas by reading the information stored on the tag (Lee and Allaway, 2002). Another advantage of the system is constantly having the items available on the shelves for customers. Because of the better control of inventory, customers can be assured the products they desire will almost always be available (Belkin, 2004). Lastly, time spent at the checkout counter can be reduced. It is hoped that the future of RFID tags will allow customers to omit walking thru the traditional checkout line. The new idea may be walking thru an exit that would read all the tags and total them for payment. However, in the nearer future, it will be more likely that tags will be seen on shopping baskets and carts. The tags on them will be connected to a database where the number of baskets and carts is tracked. The managers can open additional lines for checkouts according to the number of occupied shopping baskets and carts, (Thomas, 2003).

1.8.2 Challenges for serving the people

Improving service is a difficult challenge, but for it to compliment a new and evolving technology is even more difficult. Privacy is one of the largest concerns for RFID. It may be feasible to deactivate the tag upon departure or checkout to assure customers that the tracking of the merchandise ends at the store, (Lillo, 2004). The lack of human interaction is another potential problem. Customers will have fewer encounters with employees as the process becomes more automated. Those who enjoy the interaction with the employees' assistance throughout the store may not like how RFID tags will change their trip to the retailer.

Unfortunately, the risks, uncertainties, and limited communication of the benefits to the customer can lead to low behavioural intention and slow adoption (Lee and Allaway, 2002). Many people view the technology as 'more harmful than helpful in our society' according to our research. If the customers do not see personal value in RFID, then the likeliness that they will readily adopt it dramatically decreases.

Customers must acquire knowledge on RFID and alter their current behaviours in order for it to become accepted to customers and ultimately cause RFID to generate benefits from utilising the system (Lee and Allaway, 2002). Educating purchasers will build customer loyalty. It needs to be understood that implementing this technology can prove advantages for customers. The excellent inventory controls will provide more goods on the shelves when customers need them. Loyalty can be achieved by a retailer if it always has the items needed at the time when they are needed most. It will save time from shopping from store-to-store in hopes of finding the desired product. RFID is also beneficial to customers it can possibly reduce the price of goods. Costs are reduced because of the reduction of thievery when RFID is applied to the operation. Additionally, it is the hope of manufacturers that the price of the tags will be pennies, and the hardware and software needed to sustain the system will also be reduced by cutting the price of goods. Businesses ultimately have the capabilities of improving their customers' loyalty by using RFID.

Lastly, creating shared beliefs and an understanding of the benefits of the new technology among its users helps to speed the adoption process. According to Amoako-Gyampah and Salam (2003), "encouraging results on the role of external factors such as training and communication and the influence of beliefs on attitude and the mediation effect of attitude on the behavioural intention to use an ERP system" (p.743). Even though their study dealt with the diffusions of ERP systems, this is extremely similar to self-service checkouts and RFID technology and can also be used to discover how to enhance their diffusion process. Amoako-Gyampah and Salam (2003) help to establish a connection between ERP systems and RFID technologies when they state, "ERP systems by their very nature require simultaneous changes in business processes and information sharing and use that make it very difficult to implement" (p.742). RFID can encounter similar problems since its technologies also require these same changes and large amounts of information sharing. However, strategies that effectively work in encouraging people to adopt ERP systems will most likely work for RFID technology as well. Therefore, RFID may also receive the same encouraging results of wide spread adoption if companies will help users understand the benefits and create shared beliefs.

The aforementioned information explains that there are multiple factors that determine the success of adopting a technology. Self-checkouts have already started to diffuse into the retail environment. However, their adoption, has not been as quick as many retailers hoped. According to Bitner *et al.* (2002) "…SST [self-service technologies] such as grocery store self-scanning have been slow to catch on" (p.97). RFID, however, can have a much faster acceptance rate than self-checkouts due to several factors. In addition to implementing the aforementioned factors to increase adoption among users of new technology, RFID has additional advantages that could allow for rapid diffusion. These advantages include familiarity with using self-service technology in a retail environment for both the providers and customers and relative advantage.

Although self-checkouts have been slow to catch on, customers are becoming more accustom to and may actual enjoy using the aid of technology when they shop. Lach (1999) emphasised that consumers are starting to realise the advantages of using self-service technologies in a retail environment. Since customers already appreciate the benefits that self-checkouts have to offer, they will be even more likely to accept RFID and related automatic identification systems when they are ware of the additional benefits it has to offer. Not only are customers familiar with the new technology and therefore will be more likely to use it, but employees are also more familiar with it and, therefore, will be more likely to promote it. Self-checkouts have been around for a short time, however, they have been difficult to install and use for some companies. Bitner *et al.* (2002) reinforced this when they state, "as companies race to introduce technology that enables customers to get service on their own, managers often find that implementing and managing effective Self-Service Technologies (SSTs) is more difficult than it looks" (p.96). Since employees will already have familiarity with using SSTs, employees can adjust more easily to using RFID. If employees are more comfortable using RFID and related automatic identification systems, then they will also be more likely to promote it.

2 Methodology and results

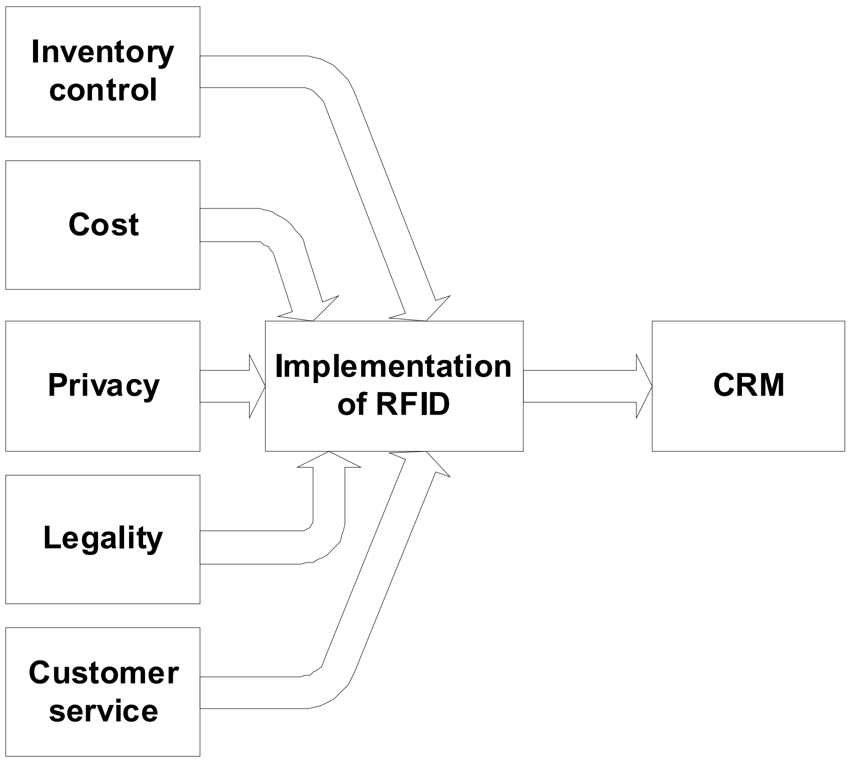
2.1 Sample characteristics and statistical techniques

Since on retail level, RFID and self-checkouts are similar, self-checkouts were used as a substitute in the survey to gauge consumer comfort with automated technology. This was completed in order to gauge reactions to respondents of the questionnaire to a fairly similar technology in B2C applications, namely self-checkouts, instead of typically B2B SCM applications associated with RFID-related applications. In theory, using self-checkouts as a proxy for RFID applications allows an investigation of potential consumers' acceptance of self-service technology to be determined when applied to a retail environment. This could then transfer to the consumers' likeliness of adopting RFID technology since the two technologies are very similar in application, at least in the B2C interface. Ultimately, this will allow the prediction of how easily RFID technology will be accepted by consumers.

Some of the more important aspects of automatic-identification technologies were presented to respondents, including previous experience with self-checkouts, reasons for using self-checkouts, positive and negative experiences with self-checkouts, privacy and comfort issues, and related CRM concerns. A variety of perspectives has been explored to portray some of the major views on automatic-identification technologies. However, there is a need to empirically explore, in more detail, the underlying motivations on the part of the customer relations in terms of IT products and/or services.

However, a number of statistical techniques are used to test specific hypotheses that deal with the elements in the model to support the various research propositions inherent in the model presented in Figure 1. As a result, a total of 75 fully employed, professional and semi-professional service management and internet users were sampled, representing a college-educated and knowledge-based sample derived from the metropolitan section of Pittsburgh, PA. A number of medium-sized companies in the service sector were selected due to time and convenience factors and 75 out of possible 300+ individuals were successfully interviewed for the purposes of this study, representing an assortment of backgrounds, age groups, and gender distributions.

Figure 1 Model for retail implementation of RFID



The initial survey was collected to determine if the independent variable constructs that are outlined in Figure 1 are indeed major themes in AIDC (Automatic Identification and Data Capture)-related technologies. A relatively interesting and revealing body of knowledge was gathered from these inquiries and questions, especially in terms of the importance of CRM concepts on potential and active participants' views on quick and convenient automatic identification protocols as related to self serve-checkouts. A variety of data reduction techniques (factor analysis and Principle Components Analysis (PCA)), multiple regression, graphical analyses, and cross-tabulation procedures were employed to accomplish testing the validity of the model. However, principal components and factor analyses techniques were be the dominant multivariate statistical procedures to be used in this research effort.

The respondents were represented by young working people, among the ages ranging from 18 to 24 years (49%), followed by 25 to 34 years olds (31%), 45 to 54 year olds (11%), 35 to 44 year olds (8%), and finally the 55 and older age bracket (1%). The younger group is probably more exposed to technology and, it is assumed that they would feel comfortable in using and learning how to use new technology. From gender perspective, 64% were male, while women accounted for 36%. While self-checkouts have just begun to become more prevalent in retail stores, approximately 83% of the respondents have used self-checkout when purchasing an item. This is especially surprising considering that the majority of respondents were males, who are not typically referred to as being heavy shoppers. However, while the majority of participants in the survey have used self-checkouts, their experiences, comfort level, and reasons for using self checkout may greatly differ, as evident in Figure 2. As evident in the graphs in Figure 1, a sizeable information was collected regarding people's knowledge on self-checkouts, their usage of self-checkouts, their comfort level regarding self-checkouts, and their likelihood of future usage. The basic research theorises that younger customers will be more comfortable using self-checkout than their older counterparts. Self-checkouts could become widely popular because when people use them, they almost always have a positive experience. This shows that regardless of people's opinions on how technology affects society, they will continue to use technology. Figure 2 shows a number of interesting relationships when graphical cross-tabulations of frequency of using self-checkouts as a grocery option (dependent variable in the hypothesis-testing phase) versus the perceptions associated automated systems.

Figure 2 Cross-tabulation of frequency of using self-checkouts grocery options versus the perceptions associated automated systems

A. Previous experience with self-checkouts

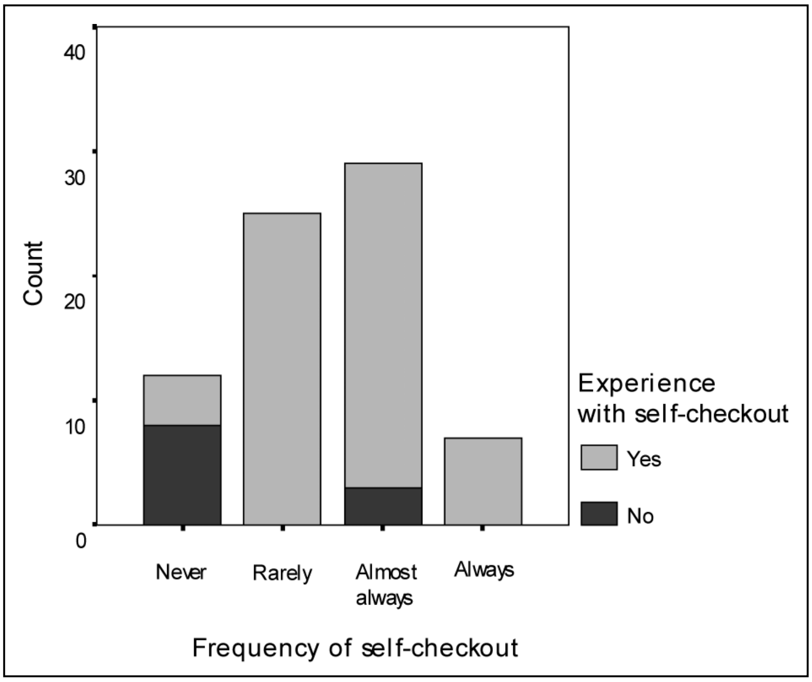
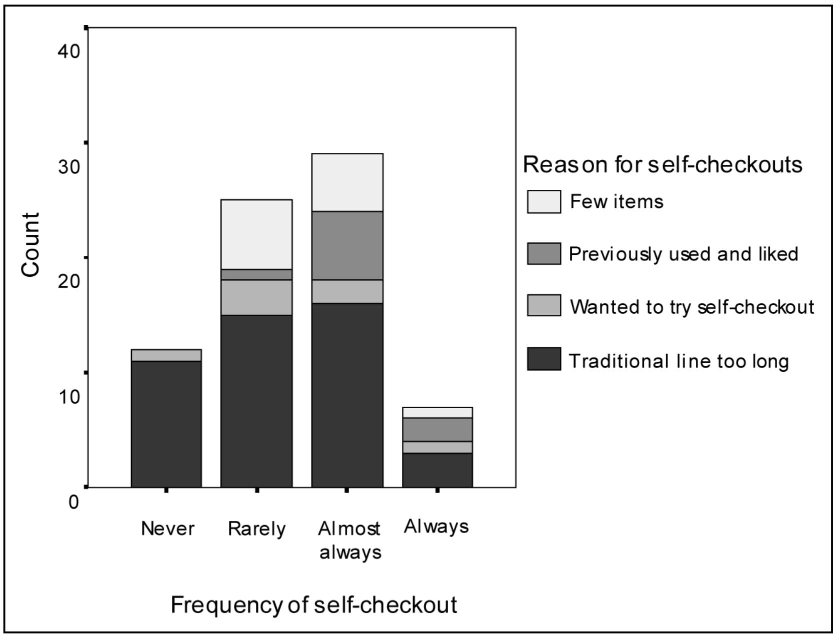


Figure 2 Cross-tabulation of frequency of using self-checkouts grocery options versus the perceptions associated automated systems (continued)

B. Reasons for using self-checkouts



C. Positive experience with self-checkouts

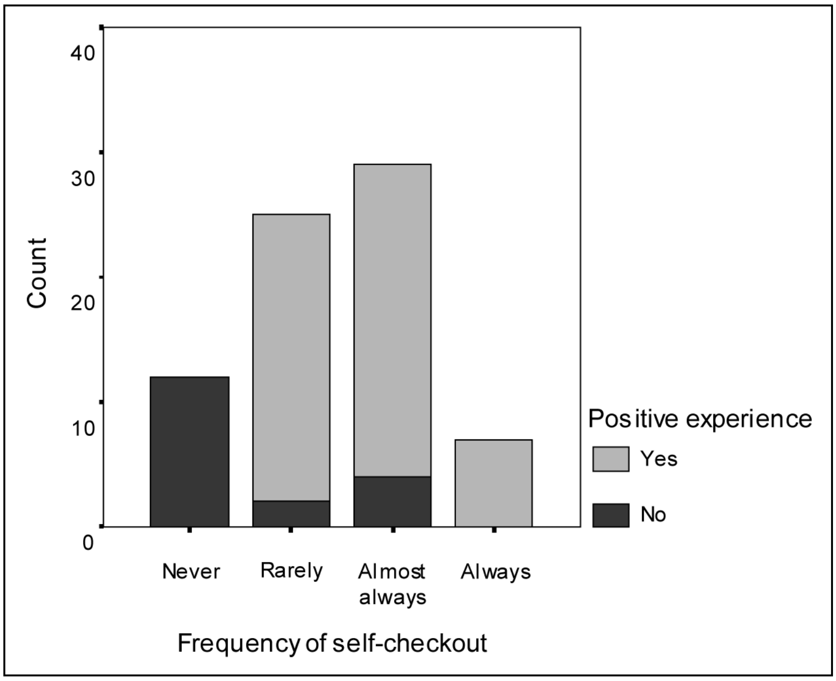
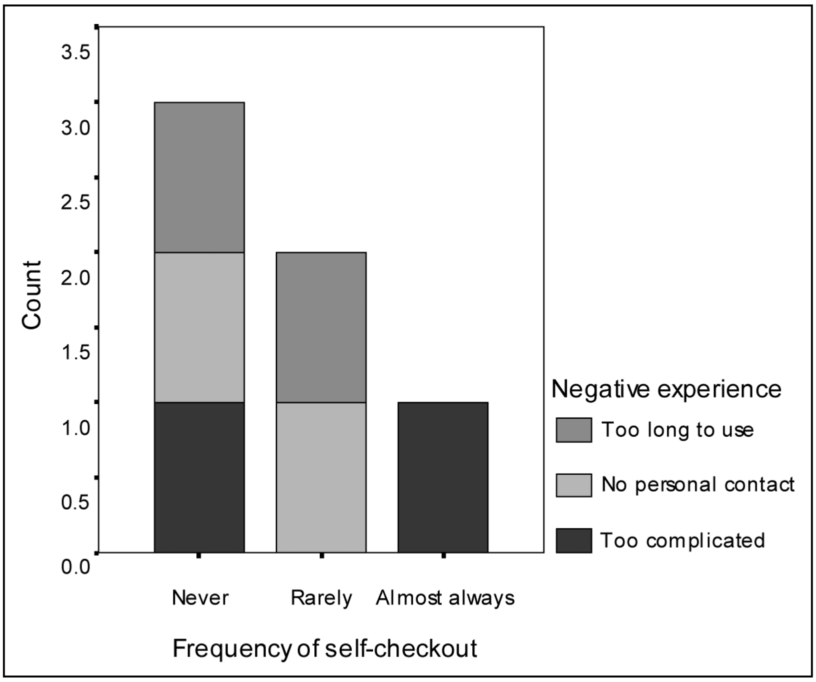


Figure 2 Cross-tabulation of frequency of using self-checkouts grocery options versus the perceptions associated automated systems (continued)

D. Negative experience with self-checkouts



E. If given the choice, prefer tradition face-to-face versus self-serve checkouts

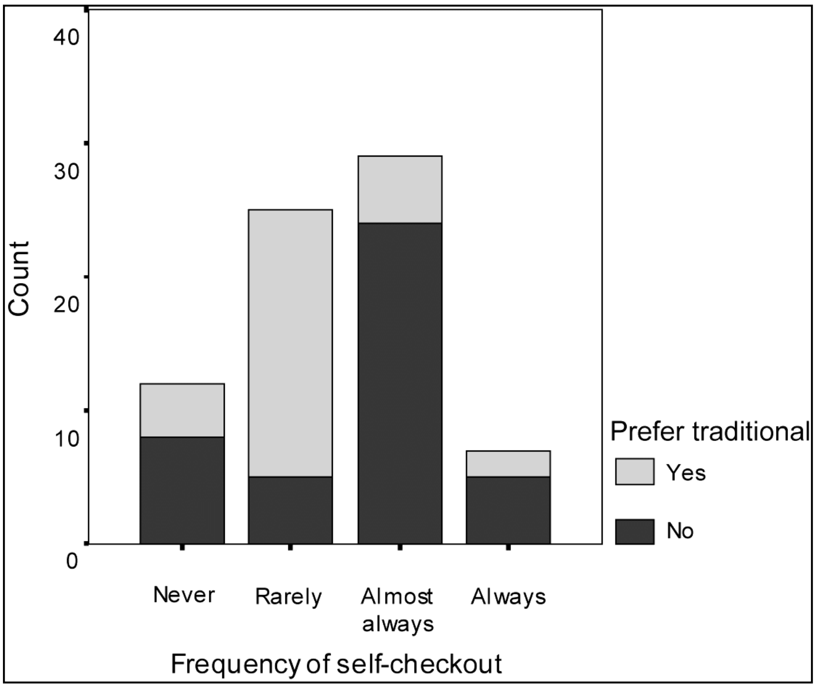
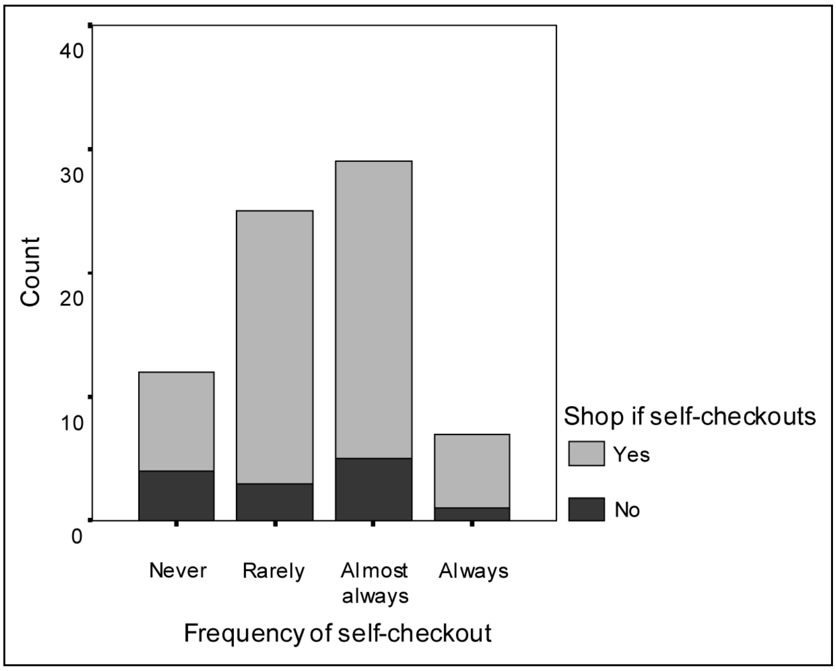


Figure 2 Cross-tabulation of frequency of using self-checkouts grocery options versus the perceptions associated automated systems (continued)

F. Continue to shop at retail location if self-serve checkouts only option



G. Rating of comfort level using self-serve checkouts

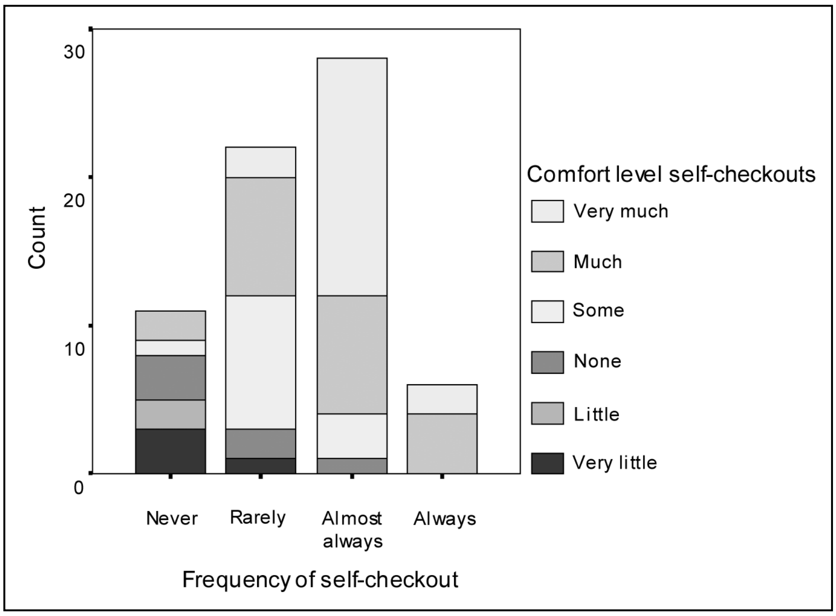
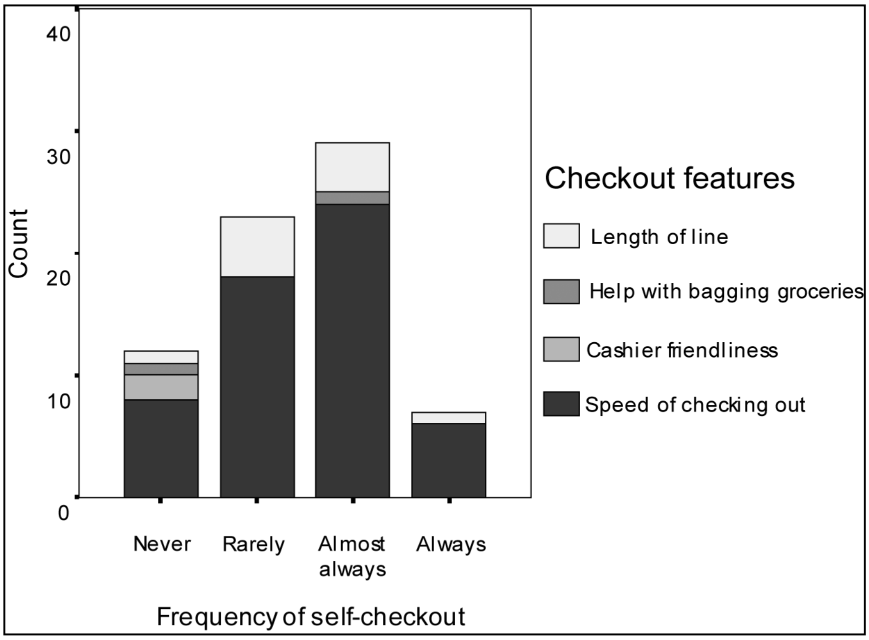


Figure 2 Cross-tabulation of frequency of using self-checkouts grocery options versus the perceptions associated automated systems (continued)

H. Main reasons for preferring self-serve checkouts



I. Rating of privacy comfort levels associated with self-serve checkouts

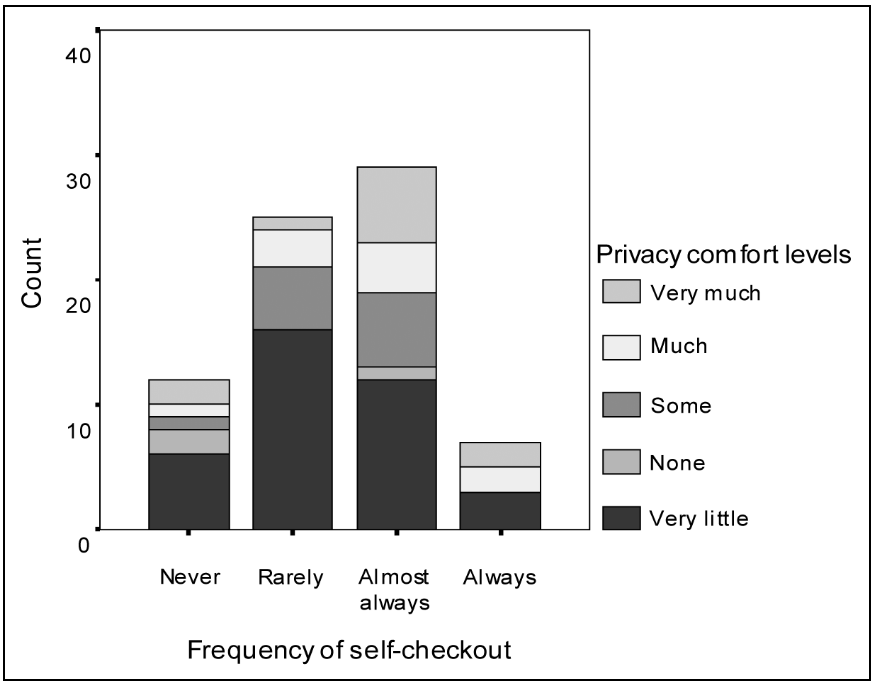
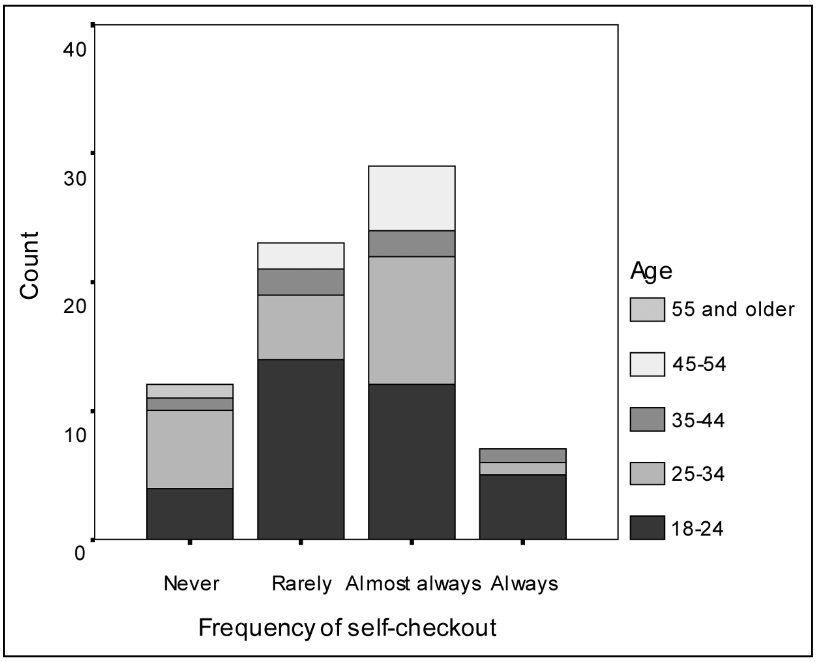
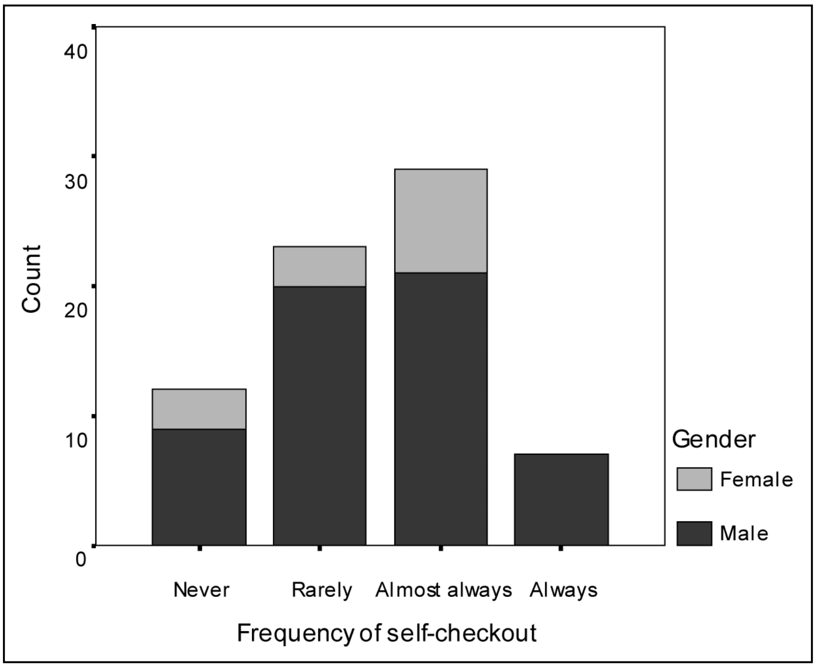


Figure 2 Cross-tabulation of frequency of using self-checkouts grocery options versus the perceptions associated automated systems (continued)

J. Age of respondent



K. Gender of respondent



Principal Component Analysis (PCA) is a classical linear transform statistical method, which has been widely used in data analysis and compression (Bishop, 1995; Cumming, 1993). The technique is based on the statistical representation of a random variable X (Oja, 1989). For p such random variables:

$$X' = [X_1, X_2, ..., X_p]. \tag{1}$$

The objective of PCA is to make p linear combinations of these variables in such a way that each captures as much of the variation in X as possible. In doing so though, each of the principal components must be linearly independent of the others. Thus, the linear combination of a principal component Y_j, of p variables with unknown coefficients $\hat{\beta}_1, \hat{\beta}_2, ...\hat{\beta}_p$, is given by:

$$Y_j = \hat{\beta}_1, X_{1j} + \hat{\beta}_2 X_{2j} + \ldots + \hat{\beta}_p X_{pj}, \qquad \text{for} \;\; j = 1, 2, ..., n. \tag{2}$$

Equation (2) can be represented using a matrix notation of the form:

$$\hat{\beta} = \begin{bmatrix} \hat{\beta}_1 \\ \hat{\beta}_2 \\ . \\ . \\ . \\ \hat{\beta}_p \end{bmatrix}, \quad Y = \begin{bmatrix} Y_1 \\ Y_2 \\ . \\ . \\ . \\ Y_p \end{bmatrix}, \quad \text{and} \quad X = \begin{bmatrix} X_{11} & X_{21} & . & . & . & X_{p1} \\ X_{12} & X_{22} & . & . & . & X_{p2} \\ . & . & & & & . \\ . & . & & & & . \\ . & . & & & & . \\ X_{1n} & X_{2n} & . & . & . & X_{pn} \end{bmatrix}.$$

With this matrix representation, the principal component can be written as:

$$Y = X\hat{\beta}. \tag{3}$$

In general, if the data are concentrated in a linear subspace, then this provides a way to compress data without losing much information and simplifying the representation. Hence, by picking the eigenvectors having the largest eigenvalues, little information as possible in the mean-square sense is lost. Therefore, by choosing a fixed number of eigenvectors and their respective eigenvalues, hopefully a consistent representation, or abstraction of the data will emerge. This procedure preserves a varying amount of energy of the original data. Alternatively, we can choose approximately the same amount of energy and a varying amount of eigenvectors and their respective eigenvalues.

This would, in turn, give approximately consistent amount of information at the expense of varying representations with regard to the dimension of the subspace. Unfortunately, when using principal conpoments analysis, there are contradictory goals. On one hand, we should simplify the problem by reducing the dimension of the representation. On the other hand, the other alternative is to preserve as much of the original information content as possible. PCA offers a convenient way to control the trade-off between losing information and simplifying the problem at hand. Thus, it may be possible to create piecewise linear models by dividing the input data to smaller regions and fitting linear models locally to the data. However, PCA is only a transformation process.

The factor analysis process is a representation of the general case by disregarding components of the input vector that are either composed of independent or dependent variables. This arrangement will have not committed the reseacher to a certain relationship among the vector components or named any components as the inputs or the outputs of the researched relationships consumer behaviour towards file sharing activities. Therefore, through these statistical procedures the ability to constrain any component of the input vector to be constant and to fetch the rest of the vector values with the aid of known values will be possible. Suppose that as in Equation (4), *p* is the set of responses for the multivariate system of interest. Then, the general factor analysis model is:

$$Y_j = \hat{\beta}_1, X_{1j} + \hat{\beta}_2 X_{2j} + \ldots + \hat{\beta}_m X_{mj} + d_j U_j, \quad \text{for} \quad j = 1, 2, ..., n. \tag{4}$$

Each of the *m* terms in Equation (4) represents factor contributions to the linear composite while the last is the error term.

2.2 Basic descriptive statistics

Tables 1 to 3 have dealt with categorical variables that are not appropriate for scale-type data measurements and warrant separate attention. As evident from the frequencies found in these tables, most customers felt that the traditional, non-automated checkout lines were too long (62.2%), very few had negative experiences (8%), and the speed of the self-checkout line was the most positive experience (79.5%). These findings are very consistent with the research propositions previously discussed.

Table 1 Frequencies associated with major reasons for self-checkout

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
Traditional line too long	46	61.3	62.2	62.2
Wanted to try self-checkout	7	9.3	9.5	71.6
Previously used and liked	9	12.0	12.2	83.8
Few items	12	16.0	16.2	100.0
Total	74	98.7	100.0	
Missing	1	1.3		
Total	75	100.0		

Table 2 Frequencies associated with major negative experiences associated with self-checkout

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
Too complicated	2	2.7	33.3	33.3
No personal contact	2	2.7	33.3	66.7
Too long to use	2	2.7	33.3	100.0
Total	6	8.0	100.0	
Missing	69	92.0		
Total	75	100.0		

Table 3 Frequencies associated with major positive experiences associated with self-checkout

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
Speed of checking out	58	77.3	79.5	79.5
Cashier friendliness	2	2.7	2.7	82.2
Help with bagging groceries	2	2.7	2.7	84.9
Length of line	11	14.7	15.1	100.0
Total	73	97.3	100.0	
Missing	2	2.7		
Total	75	100.0		

In terms of determining if younger customers would be more comfortable using self-checkouts, a simple Pearson Chi-square test ($p = 0.437$) yielded no significant differences in terms of frequency distributions among the age groups in terms of comfort level. Not only were virtually all ages fairly comfortable with automated checkouts, but most customers also shared that they had almost always a positive experience using the technology. Of the 64 respondents, only nine have had a negative experience; and of those nine, three reported that they have never used self-checkout. This is positive evidence that most customers without much hesitation should adopt the transparency of AIDC-related technologies such as automated checkouts and related RFID technologies. The Chi-square test results ($p = 0.000$) illustrated that there was a very significant relationship between having a positive experience and how often self-checkouts are used. Therefore, retailers need to ensure that consumers have a positive experience in order to increase the use of self-checkouts and ultimately encourage the adoption of RFID technology.

In addition, as demonstrated in Figure 2, the majority of respondents feel their privacy was protected, with only 13% felt uncomfortable with the current privacy levels when utilising self-checkouts. It is also noteworthy that of the ten respondents who would not shop at a particular retailer if self-checkout was the only option, seven of them would discontinue shopping at those stores based on other issues rather than of privacy. In fact, via Chi-square ($p = 0.019$), there was a significant relationship between privacy comfort level and the option of continuing to shop at the store should self-checkout become the only choice. Obviously, privacy is very important to shoppers and the introduction of automated technologies act as a moderating or intervening variable in dealing with privacy concerns for customers.

2.3 Factor analysis and hypothesis-testing results

In terms of factor analysis and PCA results, three independent constructs were found from the pool of interval Likert-type and binary discrete variables from the questionnaire data. The basic extraction method was PCA with the basic rotation method of varimax with Kaiser Normalisation. The three major constructs that were generated from the factor loadings, renamed based on the variables that loaded with loadings equal to greater than 0.5, included: Positive Experience, Privacy and Demographics, and Acceptability of the Technology. As displayed in Table 4 (including the dependent variable) as well as Table 5 (not including the dependent variable for hypothesis-testing purposes), the explained variances in the dataset by these three factor-score based groupings were

72.2% (Table 4) to 74.2% (Table 5). An eigenvalue greater than one criterion was used to generate the factor scores used in the analysis, as presented in Tables 6 (including the dependent variable) and Table 7 (not including the dependent variable for hypothesis-testing purposes). The dependent variable chosen to be regressed against these major independent factor-based constructs was the frequency of electing automated self-service checkouts, as used in the cross-tabulations in Figure 2. Tables 3 and 4 present the hypothesis-testing results of regressing the three independent factor-based scores or constructs against this dependent variable. Table 8 displays the ANOVA results for testing the dependent variable, frequency of use of self-checkouts, with the three constructs to complete the hypothesis-testing phase of the present study, while Table 9 illustrates the hypothesis testing and associated individual standardised beta coefficient and their statistical significance.

Table 4 Total variance explained on the three independent factor-based constructs, with dependent variable, frequency of use of self-checkouts

	Constructs	*Positive experience*	*Privacy and demographics*	*Acceptability*
Initial eigenvalues	Total	3.287	1.989	1.224
	Percentage of variance (%)	36.519	22.102	13.603
	Cumulative (%)	36.519	58.621	72.225
Extraction sums of squared loadings	Total	3.287	1.989	1.224
	Percentage of variance (%)	36.519	22.102	13.603
	Cumulative (%)	36.519	58.621	72.225
Rotation sums of squared loadings	Total	2.863	2.343	1.295
	Percentage of variance (%)	31.811	26.029	14.385
	Cumulative (%)	31.811	57.840	72.225

Note: Extraction method: principal component analysis

Table 5 Total variance explained on the three independent factor-based constructs, not including the dependent variable, frequency of use of self-checkouts

	Independent constructs	*Positive experience*	*Privacy and demographics*	*Acceptability*
Initial eigenvalues	Total	3.035	1.694	1.209
	Percentage of variance (%)	37.938	21.175	15.108
	Cumulative (%)	37.938	59.113	74.221
Extraction sums of squared loadings	Total	3.035	1.694	1.209
	Percentage of variance (%)	37.938	21.175	15.108
	Cumulative (%)	37.938	59.113	74.221
Rotation sums of squared loadings	Total	2.472	2.233	1.233
	Percentage of variance (%)	30.894	27.915	15.413
	Cumulative (%)	30.894	58.809	74.221

Note: Extraction method: principal component analysis

Table 6 Varimax rotated-component matrix displaying the factor loadings into each major independent construct, in decreased order of importance, including the dependent variable, frequency of use of self-checkouts

	Positive experience	*Privacy and demographics*	*Acceptability*
Experience with self-checkout	0.759	–0.177	0.448
Positive experience	0.851	–0.267	0.171
Traditional over self-checkout	–8.345E–02	–3.364E–02	0.944
Shop if self-checkout only option	0.376	–0.573	–0.198
Comfort level self-checkout	0.836	–2.174E–02	–0.217
Privacy comfort level	0.206	0.742	–9.780E–02
Age	–0.200	0.854	–1.747E–02
Gender	–9.815E–02	0.790	–9.396E–02
Frequency of self-checkout	0.788	7.404E–02	–0.263

Notes: Extraction method: principal component analysis
Rotation method: varimax with Kaiser normalisation
Rotation converged in four iterations

Table 7 Varimax rotated-component matrix displaying the factor loadings into each major independent construct, in decreased order of importance, including the dependent variable, frequency of use of self-checkouts

	Positive experience	*Privacy and demographics*	*Acceptability*
Experience with self-checkout	0.839	–0.116	0.325
Positive experience	0.880	–0.199	5.719E–02
Traditional over self-checkout	4.826E–02	–7.828E–02	0.936
Shop if self-checkout only option	0.478	–0.479	–0.360
Comfort level self-checkout	0.795	6.037E–02	–0.310
Privacy comfort level	0.178	0.792	–0.137
Age	–0.271	0.834	5.136E–02
Gender	–0.165	0.787	–4.569E–02

Notes: Extraction method: principal component analysis
Rotation method: varimax with Kaiser normalisation
Rotation converged in four iterations

Table 8 ANOVA results for testing the dependent variable, frequency of use of self-checkouts, with the three constructs derived from the model presented in Figure 1

A. Model summary

R	*R square*	*Adjusted R square*	*Standard error of the estimate*
0.650	0.423	0.396	0.68

Note: Predictors: (Constant), REGR factor score three for analysis, REGR factor score two for analysis, REGR factor score one for analysis

B. ANOVA results

	Sum of squares	*df*	*Mean square*	*F*	*Significance*
Regression (combined constructs)	21.340	3	7.113	15.396	0.000
Residual	29.108	63	0.462		
Total	50.448	66			

Notes: Predictors: (constant), REGR factor score three for analysis, REGR factor score two for analysis, REGR factor score one for analysis

Dependent variable: frequency of self-checkout

Table 9 Hypothesis-testing and associated coefficient results with the dependent variable, frequency of use of self-checkouts, versus the independent constructs

	Unstandardised coefficients		*Standardised coefficients*	*t*	*Significance*
	B	*Standard error*	*Beta*		
Constant	2.433	0.083		29.296	0.000
REGR factor score one for analysis (positive experience)	0.524	0.084	0.599	6.264	0.000
REGR factor score two for analysis (privacy and demographics)	7.547E–02	0.084	0.086	0.902	0.370
REGR factor score three for analysis (acceptability)	–0.207	0.084	–0.237	–2.478	0.016

Note: Dependent variable: frequency of self-checkout

Interestingly, although the combined predictive relationship was found to be statistically very significant (F = 15.396, p = 0.000), the individual standardised beta coefficients (Table 7), found that the independent constructs of Positive Experience (t = 6.296, p = 0.000) and Acceptability of Technology (t = –2.478, p = 0.016) were the most important factors in predicting the frequency of use of such automated technologies in the retail grocery setting.

3 General conclusions and implications

RFID and other AIDC-related technologies can prove to be very advantageous in the B2C as well as the more traditional B2B industries, as inferred on the automated self-serve checkouts. It is recommended – to best implement such a system – that at least three basic steps are checked to ensure a successful execution. Initially, a cost-benefit analysis should be conducted for companies to evaluate its particular needs. Next, solutions provider with applications experience and a complete understanding of the B2C environment with an appreciation of CRM principles should be employed. They can offer insights to future problems and concerns, which include the usage of software, middleware, hardware, and the required integration and implementation of services. Third, the entire organisation and its stakeholders, including potential customers, should be educated on using of such technology for successful adoption (Geissler and Edison, 2003). They need to understand how it works, its benefits, and changes that will occur as a result of implementing automated technologies.

Alternatively, customers' perceptions of the technology have a significant effect on success rate of implementing the system. From the present study, there are a number of ways in which a company can aid and speed up the adoption process for the customers. Developed attitudes toward the technology need a favourable view. Companies will need to create positive associations with automated identification systems, such as self-checkouts and RFID, with their shopping experience. The perception of control over the experience with technology needs to be strongly communicated. A slow implementation of automated identification systems is required to fulfill this. This reduced pace should help potential customers develop a strong comfort level over a longer period of time by providing them options to exercise traditional versus automated solutions. The level of complexity of the innovation must be managed through the use of product and service demonstrations and explanations of the purpose of how automated identification systems can help simplify the process. In addition, it cannot be underestimated that managers should establish creditability that they have the value-added interests of the customer in mind by communicating a sense of shared beliefs and understanding benefits of the innovation. It should also be ensured that appropriate concepts of CRM are adhered to be just as important to the success of implementation as the business operational aspects of automated identification systems.

A company can realise many benefits through an application of automated identification systems, especially by enhanced customer loyalty and repeat purchasing. The B2C relationship should drastically be improved by enhanced CRM via the leveraging of RFID and other automated identification systems. Services offered to the customers must the common goal of management. Implementing automated identification systems in the B2C environment may eventually serve as a new model for improving competition and improving each business' operations.

References

Albrecht, K. (2002) 'Supermarket cards: the tip of the retail surveillance iceberg', *Denver University Law Review*, Summer, Vol. 79, No. 4, pp.534–539,558–565.

Alorie, G. (2004) 'U.S. pushes for RFID laws', *CNET News.com*, February, Online Available http://networks.silicon.com/lans/0,39024663,39118626,00.htm

Amoako-Gyampah, K. and Salam, A. (2003) 'An extension of the technology acceptance model in an ERP implementation environment', *Information and Management*, Vol. 42, pp.731–745.

Barthiaume, D. (2004) 'How to ensure a successful RFID pilot', *Chain Store Age*, Vol. 80, No. 4, pp.43–44.

Beaver street fisheries stands to benefit from Wal-Mart's RFID mandate (2004) 'Beaver street fisheries stands to benefit from Wal-Mart's RFID mandate', *Manufacturing Systems Institute*, Vol. 22, No. 10, p.52.

Bednarz, A., Dubie, D. and Langford, R. (2003) 'Playing tag', *Network World*, July, Vol. 20, No. 27, pp.41–43.

Belkin, G. (2004) 'Do RFID advocates consider the customer?', *Chain Store Age: Retail Technology Quarterly*, January, p.36A.

Bishop, C.M. (1995) *Neural Networks for Pattern Recognition*, Oxford, UK: Oxford University Press.

Bitner, M., Ostrom, A. and Meuter, M. (2002) 'Implementing successful self-service technologies', *Academy of Management Executive*, Vol. 16, No. 4, pp.96–108.

Boone, T. (2004) 'The art of deploying RFID: three tips', *Frontline Solutions*, Vol. 5, No. 10, pp.33–34.

Boyle, E. (2002) 'RFID labels a good read', *Paper, Film, and Foil Converter*, April, Vol. 76, No. 4.

Brandel, M. (2003) 'Smart tags, high costs', *Computerworld*, December, Vol. 37, No. 50, pp.39–40.

Cline, J. (2004) 'The RFID privacy scare is overblown', *Computerworld*, 15 March, p.44.

Cumming, S. (1993) 'Neural networks for monitoring of engine condition data', *Neural Computing and Applications*, Vol. 1, No. 1, pp.96–102.

Dipert, B. (2004) 'RFIDs confront the venerable bar code', *EDN (The Design Source for Engineers and Managers Worldwide)*, 14 October, Vol. 49, No. 21, p.14.

Dunn, R. (2004) 'For better or worse', *Chain Store Age*, June, Vol. 80, No. 6, p.52.

Geissler, S. and Edison, G. (2003) 'Measuring attitudes towards general technology: antecedents, hypotheses and scale development', *Journal of Targeting, Measurement and Analysis for Marketing*, Vol. 12, No. 2, pp.137–139.

Holland, T. (2004) 'Shopping-cart spy chips', *Far Eastern Economic Review*, 9 September, Vol. 167, No. 36, pp.36–44.

Kevan, T. (2004) 'Going bilingual with multipurpose readers', *Frontline Solutions*, Vol. 5, No. 8, pp.24–27.

Kinsella, B. (2003) 'The wal-mart factor', *Industrial Engineer*, Vol. 35, No. 11, pp.32–36.

Kinsella, B. and Elliott, M. (2005) 'Delivering the goods', *Industrial Engineer*, March, Vol. 37, No. 3, pp.24–30.

Lach, J. (1999) 'Scan it yourself', *American Demographics*, Vol. 21, No. 9, pp.11–13.

Lee, J. and Allaway, A. (2002) 'Effects of personal control on adoption of self-service technology innovations', *The Journal of Services Marketing*, Vol. 16, No. 6, pp.553–572.

Lillo, A. (2004) 'Store of the future is here today', *Home Textiles Today*, January, Vol. 25, No. 19, pp.11–12.

McClenahen, J. and Purdum, T. (2004) 'RFID's ROI', *Industry Week*, November, Vol. 253, No. 11, p.67.

Murphy, T. (2004) 'Radio frequency ID', *World's Auto World*, June, Vol. 40, No. 6, p.21.

Oja, E. (1989) 'Neural networks, principal components, and subspaces', *International Journal of Neural Systems*, Vol. 1, No. 1, pp.61–68.

Pottie, G.J. (2004) 'Privacy in the global e-village', *Association for Computing Machinery, Communications of the ACM*, Vol. 47, No. 2, pp.21–29.

Praskey, S. (2004) 'Call of the wire', *Canadian Grocer*, Vol. 118, No. 4, pp.58–61.

RFID: good or bad (2004) 'RFID: good or bad', *International Journal of Productivity and Performance Management*, Vol. 53, Nos. 5–6, pp.565–573.

Samwel, E. (2004) 'Collaboration is key to RFID', *Journal of Commerce*, p.1.

Security friend and foe (2003) 'Security friend and foe', *Industrial Engineer*, Vol. 35, No. 11, p.39.

Shutzberg, L. (2004) 'Early adopters should be wary of RFID costs', *Informationweek*, November, No. 1012, p.98.

Smith, A.D. (2002) 'Loyalty and e-marketing issues: customer retention on the web', *Quarterly Journal of E-commerce*, Vol. 3, No. 2, pp.149–161.

Smith, A.D. (2004) 'Potential for growth and security in internet file-sharing: the VPN concept of gnutella', *Journal of Internet Commerce*, Vol. 3, No. 2, pp.1–19.

Smith, A.D. and Offodile, O.F. (2002) 'Information management of automated data capture: an overview of technical developments', *Information Management and Computer Security*, Vol. 10, No. 3, pp.109–118.

Smith, A.D. and Rupp, W.T. (2002a) 'Application Service Providers (ASP): moving downstream to enhance competitive advantage', *Information Management and Computer Security*, Vol. 10, No. 2, pp.64–72.

Smith, A.D. and Rupp, W.T. (2002b) 'Issues in cybersecurity: understanding the potential risks associated with hackers/crackers', *Information Management and Computer Security*, Vol. 10, No. 4, pp.178–183.

Thomas, D. (2003) 'Retailers not prepared for RFID processes', *Computer Weekly*, 16 December, p.10.

Traiman, S. (2001) 'Tag, you're it! The EPC tag could revolutionize the retail supply chain', *Retail Systems Reseller*, November, Online, Available http://www.retailsystemsreseller.com/archive/Nov01/Nov01_5.shtml

Want, R. (2004) 'The magic of RFID', *ACM Queue*, Vol. 2, No. 7, Online, Available http://www.acmqueue.com/modules.php?name=Content&pa=showpage&pid=216&page=1

Wood, L. (2004) 'Retail's biggest RFID project', *Chain Store Age: Retail Technology Quarterly*, October, pp.11A–19A.

Notes

1. Auto ID Center Technology Guide (2003) Online, Available http://archive.epcglobalinc.org/new_media/brochures/Technology_Guide.pdf
2. Radio Frequency Identification (RFID) (2004) Retrieved 9 December, http://en.wikipedia.org/wiki/RFID
3. RFID in Retail: the Future is Now (2003) LakeWest Group, LLC, June, Online, Available http://www.lakewest.com/PDFdocs/RFID%20In%20Retail%20The%20Future%20Is%20Now_June%202003.pdf
4. Radio Frequency Identification (RFID): critical considerations for manufacturers (2005) Radio Frequency Identification (RFID): critical considerations for manufacturers', *Deloitte.com*, Online, Available http://www.deloitte.com/dtt/research/0,1015,sid%253D23805%2526cid%253D33922,00.html