RFID Integrated Systems in Libraries: Extending TAM Model for Empirically Examining the Use

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Abstract

Purpose: The available literature suggest that the research on RFID related issues is largely concentrated on technical, organizational and implementation aspects, and comparatively lesser attention has been invested in understanding the use aspect of such library management systems. This article thereby aims at gaining an understanding into the factors that influence the use of Radio Frequency Identification (RFID) systems in the library context by empirically testing the relevant constructs from the extended Technology Acceptance Model (TAM) model.

Methodology: A questionnaire based survey approach was employed for collecting the relevant data from 197 respondents. The respondents were the active users of a RFID based library system.

Findings: Findings from this study suggested that perceived usefulness and system quality positively influence the user attitude, and user attitude and system quality significantly influence the use of the RFID services. The paper concludes with outlining the salient points, limitations, and future research directions

Originality/value: The paper evaluates the role of a set of innovation attributes on the acceptance of RFID integrated systems in libraries. Owing to the scant literature availability in empirical investigations on adoption of RFID systems in libraries, the findings from this study add value to the existing literature in this field, and also to the literature on the TAM model, with the empirical findings being of use to the aspirant libraries looking towards integrating RFID enabled systems.

Keywords: Adoption, TAM, RFID, Use.

Article Type: Research Paper

1. Introduction

Operating and managing libraries, particularly the larger ones, involves undertaking numerous repetitive tasks; such tasks include, but are not limited to – tagging new items, shelving, issuing items to users, issuing alerts against late returns, re-shelving after returns, managing inventory, protecting items from theft. These tasks are not only repetitive, but are meticulous involving considerable amount of labour/effort and time. Manual operations of such tasks demand high levels of resources in terms of number of people required, and the amount of time and budget required, which are all likely of introducing human errors, thus affecting both, the efficiency and effectiveness of a library operation system. With hopes of increasing efficiency and effectiveness, many libraries are adopting the automation of the tasks outlined above. In doing so, the *Radio Frequency Identification (RFID)* technology is being deployed to play the vital role of efficient management in library automations (Sing et al., 2013). The *RFID* technology has revolutionized the item identification and tracking system. This technology allows automated identification of products by embedding chips with wireless antennas on objects (Bose et al., 2009; HanataniI et al., 2012). In a typical RFID system, the radio waves are generated, modulated, amplified and then transmitted by a radio frequency transmitter through an antenna. These radio waves in turn are received and processed by the RFID tags, which send back a unique identification code and other data via radio waves to a radio frequency receiver (Ampatzidis and Vougioukas, 2009). In the library context, the RFID tags are embedded within the objects of interest (such as books, journals, DVDs etc) and the receiver is integrated within various systems such as the self-checkout system, the security system and the inventory management system (Dwivedi et al., 2013).

RFID tagging of objects has now become the successor of barcodes, particularly in the libraries. Libraries are a fast growing application of RFID as the technology promises to relieve repetitive strain injury of staffs, speed up the patron self-checkout, and make possible comprehensive inventory management (Molnar and Wagner, 2004, p25). According to Ayre (2005), in the late 1990s the libraries began using RFID as a substitute for the electro-magnetic and bar coding systems. Since then RFID has served an imperative role in redefining the library processes for simplifying the library tasks for both, the users and the library staff. It provides a platform to automate a majority of the processes executed by the library staff.

Due to its effective role in item identification and tracking (Du, 2012; Zhang et al., 2012), the RFID technology has been adopted across various fields (Shahzad and Liu, 2012). Daily streams witness RFID assisting in preventing theft of goods and automobiles, traffic control, automated parking management and vehicle access control, in business campuses and airports, ski lifting, inventory, supply chain management and many more (Juban and Wyld, 2004; Reyes and Frazier, 2007). Farms now use RFID tags to track their animals, while there are others that use these tags to search lost pets. Warehouses and supermarkets are tagging their goods for better management of their inventory (Want, 2004). The food drug administration is also using these RFID tags to identify drugs and thwart counterfeiting, and libraries (as already mentioned above) are using RFID to effectively managing their systems, and DVD's also come with these tags to prevent movie piracy (Maffia et al., 2012; O'Conner and Catherine, 2005). Logistics is also witnessing the integration of RFID systems for enhanced management (Viani et al., 2012).

While these RFID systems offer several benefits, including cost savings in the longer run (Demiralp et al., 2012), their adoption in organizational context has been slow due to a number of reasons including high cost of implementation and integration issues (Irani et al., 2010). Whilst substantial industry efforts have been invested in understanding and overcoming these technological shortcomings, very little scholarly attention has been placed in understanding the users' take on this technology. In line with this point is the argument made by Irani et al. (2010) in a recent review on this topic that the future scholarly efforts should be made in investigating the management and end user related issues that might be contributing to failure of the RFID implementation effort. For instance, studies (Pramatari and Theotokis, 2009; Rothensee and Spiekermann, 2008) from the retail domain showed that the staff and user resistances, and the related user apprehensions in adopting this technology led to the failure of such RFID implementations. It thereby becomes critical to scrutinize

the factors that influence the user approval/rejection in the other domains where the RFID application has been integrated, including the library management systems.

In reviewing the existing literature, we found that patron self check and patron satisfaction were identified as the two most imperative benefits of RFID application in libraries (Kern, 2004), and yet there are very few studies empirically examining these two benefits. The existing literature on technology adoption (for example, Anandarajan et al., 2002; Gudigantala et al., 2011; Lin, 2011; Udo et al., 2011; Wang et al., 2011) recommends the importance of gaining an understanding of the factors that affect the usage of such systems to promote their use. This research therefore aims at *examining the factors that determine use of the RFID based systems in libraries*. The proposed aim will be achieved by undertaking an empirical examination of user perceptions via an *online survey method*.

The results derived from this paper can serve as a small source usable by those considering integrating the RFID technology within their systems. This study is an attempt to probe into the *use* aspect of the user acceptance of the RFID systems. This study will be investigating the perceptions of users with respect to the user requirements being met with the use of the RFID application. Given the fact that not sufficient literature is available in this area of interest, our study may succeed as an incremental contribution in the literature pertaining to RFID.

This paper is structured as follows: section 2 presents a brief review of literature on the RFID applications and their advantages; section 3 then briefly discusses the development of the conceptual model used for this research; section 4 describes the research methodology employed to conduct this research, followed by section 5, which presents the findings from the survey data; the reported findings will then be discussed in section 6, to finally conclude with the limitations and future research directions from this study.

2. Literature review

The RFID technology is spreading at a rapid pace, creating space full of speculation concerning the advantages that its investments may have to offer (Irani et al., 2010). The library management using RFID based systems is one of the many and popular applications of this technology. The use of RFID in libraries dates back to the late 1990s. The earliest evidences in the literature suggest that the first ever probable deployment of the RFID system in the library context was in 1998, at the *Singapore Public Library* (Engel, 2006). Singapore also stands recognized as the first country in the world to implement RFID systems across all of its 21 public libraries (Ayre, 2005).

As mentioned in the previous section, apart from the two universally acknowledged advantages of RFID systems in the library context – *patron self check* and *patron satisfaction* (Kern, 2004), there are many other reported advantages of this application across the library management systems, and across other areas. Dwivedi et al. (2013) have gathered and reported some of these benefits, which are – *Automation/ elimination or reduction in labor* (Ferrer et al., 2010); *Capacity expansion* (Ferrer *et al*., 2010 ; Ngai *et al*., 2007); *Cost effective, inexpensive, easy and low maintenance* (Liu et al. 2009, Tesoriero et al. 2010); *Self service/ reduction of staff injury* (Ayre, 2005; Ching and Tai, 2009; Engel, 2006; Erwin et al., 2003; Hicks, 1999; Yu, 2007; Yu, 2008); *Enhanced customer satisfaction* (Ferrer et al., 2010; Park et al., 2008); *Facilitates communication with multiple tags simultaneously* (Abad et al., 2009; Kim and Choi, 2010; Kumar et al., 2009; Lau et al., 2010, Yu, 2007; Wang *et al*., 2010); *Faster response time/ greater speed/ reduced cycle time* (Apte et al., 2006; Coyle, 2005; Kern, 2004; Kumar et al., 2009; Tesoriero et al., 2010); *Inventory tracking and visibility/ enhanced forecasting/ reduced stock-outs/ closed loop tracking* (De Kok et al., 2008; Doerr et al., 2006; Ferrer et al., 2010; Kang and Stanley, 2005; Kumar et al., 2009, Lee et al., 2007; Lee et al., 2009; Niederman et al., 2007; Wen, 2010); *Longer lifetime* (Tesoriero et al., 2010; Coyle, 2005; Kern, 2004); *Increased data storage* (Kumar et al., 2009; Phillips et al., 2005; Wu and Yen, 2007); *No line of sight required* (Abad et al., 2009; Bansode and Desale, 2009; Kumar et al., 2009); *Reduces theft and counterfeiting* (De Kok et al., 2008; Staake et al., 2005).

< Table 1 Here>

In the view of the above mentioned benefits of RFID, Liu et al. (2009) state that this application is extremely practical, and can be very opportunely implemented. Table 1 (adapted from Dwivedi et al., 2013) is a mapping of the RFID benefits across the various identified RFID applications.

In addition to the above listed benefits, the literature also recognizes and addresses the different limitations that the implementers face with the installation and use of these RFID systems (Dwivedi et al., 2013). Some such identified limitations were – *cost* (Abad et al., 2009; Brown and Russel, 2007; Ching and Tai, 2009; Kumar et al., 2009; Roberts, 2006); *difficulty in reading tags on products with high amount of water and metals* (Kumar et al., 2009); *difficulty in reading ultra high frequency tags near a human body* (Kumar et al., 2009; Roberts, 2006); *intermittent and unreliable reads* (Rappold, 2003; Roberts, 2006; Sarma, 2004); *middleware design* (Chen et al., 2010); *multiple Items Read* (Smart and Schaper, 2004); *perpendicular orientation of the tag to the antenna of the reader make reading difficult/ large number of tagged objects randomly placed also may cause invisibility* (Want, 2004); *privacy and security* (Atkinson, 2004; Ayoade, 2006; Berthold et al., 2005; Chae et al., 2013; Edwards and Fortune, 2008; Erwin et al., 2003; Jones et al., 2004; Kelly and Erickson, 2005; Kumar et al., 2009; Mubarak et al., 2012; Muir, 2007; Roberts, 2006; Ohkubo et al., 2005; Ouafi, 2008); *recycling* (Kumar et al., 2009); *standardization* (Abad et al., 2009; Brown and Russel, 2007; Chin et al., 2008; Ching and Tai, 2009; Glover and Bhatt, 2006; Loebbecke and Huyskens, 2008); *managerial Issues* (Hildner, 2006), and *vandalism* (Coyle, 2005; Engel, 2006; Gomez-Gomez, 2007; Hopkinson and Chandrakar, 2006; Kern, 2004).

Some retail studies (Pramatari and Theotokis, 2009; Rothensee and Spiekermann, 2008) have shown in their studies that the staff resistance, user resistance, and consumer apprehensions associated with the acceptance of this technology, all contribute to the failure of its implementations. It is therefore important to study the factors affecting user acceptance/rejection of such RFID applications. The following section will now focus on presenting an account of the conceptual model and research methodology developed for this study.

3. Theoretical basis and the proposed conceptual model

One of the commonest concerns today in the issue of innovation-diffusion amongst individuals/organizations is of possible ways of speeding their diffusion processes. To address this issue from the RFID perspective, the prospective libraries would be interested in the few important factors that significantly influence the use of these RFID systems. RFID is an enhancement over the already existing barcoding system. The important question here is – would libraries choose RFID above the pre-established barcode system? In finding the answer to this question, it is important to understand if the users of these RFID enabled systems find them to be relatively better than the existing barcoding system; it is also important to know if they find these RFID equipped systems easier to use in comparison, which in turn will positively influence the acceptance of such RFID systems. Therefore, the two primary attributes of interest to our study are the *perceived usefulness* of these systems and the *perceived ease of use*.

There are numerous models available in the literature for predicting the attitude towards use and the actual use of a given innovation like – the diffusion of innovations theory (DOI), the unified theory of acceptance and use of technology (UTAUT), the theory of reasoned action (TRA), and the theory of planned behaviour (TBP). The innovation-attributes from Rogers' DOI theory have already been investigated by a number of studies in the past (Tornatzky and Klein, 1982; Greenhalgh et al., 2004; Hester and Scott, 2008; Legare et al., 2008) for studying the diffusion of different innovations. It was therefore decided to choose a different model for this study. After delving a little further in the other models it was found that the UTAUT, TRA and TBP models more or less used the same attributes. Interestingly, in addition, some studies in their findings reported TAM model to be superior in comparison to the other models; for instance – Chau and Hu (2002), in examining the adoption of telemedicine by physicians found TAM to be superior to the TPB model; Gentry and Calantone (2002), in predicting the behavioural intentions of the buyers also found TAM to be superior to both

TRA and TBP. To add, the TAM model has both attributes of most interest to this study, and therefore this model was deemed appropriate for empirically investigating the acceptance of RFID in libraries.

According to Angeles (2007), user attitude is considered as the initial trigger to any technology adoption. As Pramatari and Theotokis (2009) suggest, the user attitude towards the RFID integrated systems considerably controls the user acceptance of those systems post the integration of RFID. It was therefore decided to study the influence of TAM attributes on *attitude* as the dependent variable. Many models have been seen studying the influence of intention on the adoption aspect of an innovation (Davis et al., 1989 in TAM; Ajzen and Fishbein, 1980 in TRA; Ajzen, 2006 in TPB, Taylor and Todd, 1995 in decomposed TPB). However for this study, the effect of *attitude* will be studied on the *actual use* of an innovation.

In addition to the above identified contructs, another construct, *system quality* was paid particular interest. Given that, RFID is a technology that is particulatly integrated within the already functional systems to make their functioning and use more efficient, the idea of examining the quality of these systems post the RFID integration was thought of to be of relevance from this study's perspective. Therefore, the system quality construct was borrowed from DeLone and McLean's IS success model (2002) for this study. The TAM model was thereby extended with this attribute to account for the acceptance of RFID integrated systems in modern libraries.

In summary, it was thereby concluded that the influences of *relative Advantage*, *perceived ease of* use, and *system quality* will be examined against the *attitude* of consumers towards the RFID systems; the influence of *perceived ease of use* will also be examined against the influence on *perceived usefulness* of the RFID systems; and finally the effects of *attitude* and *system quality* will be examined for their influences on the *actual use* of the RFID systems.

< Table 2 Here>

3.1 Perceived Usefulness

This attribute measures the perceived degree of advantage than an innovation has to offer over the existing systems that it is superseding (Rogers, 2003). This attribute is found to be studied across numerous technologies. To exemplify a few – an organizational study measuring the adoption intention of distributed work arrangements showed for this innovation attribute to be positively related to the intention of use (Sia et al., 2004). Hsu et al. (2007) in their mobile internet study found that relative advantage significantly influenced the adoption intentions of the consumers. Similarly, another online portal study revealed that increased levels of offered advantage will be directly related to the increased levels of adoption intentions (Shih, 2008). The RFID integration in libraries can be viewed to be superseding the idea of barcoding items in libraries. It allows for the same management, distribution, tracking of items, but in a more time-efficient and effective manner. Thus, this attribute was considered relevant and valid in the RFID context, and included to be studied as a part of this empirical investigation.

H1: *Perceived usefulness significantly influences the attitude of users towards the acceptance of the RFID integrated systems in libraries.*

3.2 Perceived Ease of Use

Davis (1986) defines perceived ease of use as the degree to which an individual perceives that using a given innovation will be free of physical and mental effort. Teo and Lim (1996) point out that the past studies consider this attribute to be the opposite of complexity. Therefore, ease of use focuses on the ease aspect of a given innovation, and hence, it is positively related to adoption. This attribute has also been studied across varied technologies like - mobile data services, mobile payment, e-government and many more (Lu et al., 2008; Chen, 2008, Sang et al., 2009), and these studies found that ease of use positively influenced the use intentions of potential users. On the other hand, the relationship

between perceived ease of use and perceived usefulness (relative advantage) has also been demonstrated by many studies. Venkatesh et al. (2003) illustrated that easy-to- use mobile payments services are positively related to the assessment of their usefulness by the consumers. Lin (2005) in predicting the intentions of potential online shoppers found that ease of use significantly influenced usefulness. Similarly, Schierz et al. (2010) in their study on mobile payment services adoption also found that perceived ease of use significantly predicted perceived usefulness. From the above discussions it can be thus argued that a higher degree of ease will attract more consumers to use an introduced innovation, and the easiness in using that innovation will be perceived positively as an advantage of using the given innovation. The hypotheses can thus be formulated as,

H2: *Perceived ease of Use will positively influence the attitude of users towards the acceptance of the RFID integrated systems in libraries.*
H3: *Perceived ease of Use will positively influence the perceived usefulness of the RFID integrated systems in libraries.*

3.3 System Quality

System quality refers to the desirable characteristics of an information system, and thereby accounts for the usability and performance characteristics of that system (Urbach and Muller, 2011). The importance of system quality is related to the errors present in the system, its ease of use, performance stability, response time and flexibility (Wu and Wang, 2006). Kim et al. (2009), in their study on ubiquitous computing showed the significant influences of system quality on its use. A meta-analysis by Petter and McLean (2009) reported nine published studies examining the effect of system quality on use and user satisfaction, findings of which showed that overall, the system quality construct had a strong and significant influence on both use and user satisfaction constructs. In the present context it can be argued that greater the quality of RFID systems in library, greater the likelihood of that system attracting positive user intentions, and in turn being actually used. Thus, the hypotheses proposed for here are:

H4: *System quality will significantly influence the attitude of users towards the acceptance of the RFID integrated systems in libraries.*
H5: *System quality will significantly influence the use of the RFID integrated systems in libraries.*

3.4 Attitude

Social behaviours are heavily influenced by individual attitudes, and are particularly used to predict the *use* of information systems (Fishbein and Ajzen, 1975; Lin, 2008). Attitude is defined as the evaluative response to an antecedent stimulus, with its influence on the actual use being the strongest when the adoption decision is voluntary (McGuire, 1969). Given that the decision of the library users to use the RFID integrated systems for item issues/renewals/returns is completely voluntary, examining the impact of attitude on adoption would substantially contribute towards the understanding of the use of these RFID systems installed in the libraries. The hypothesis therefore proposed in this context was –

H6: *Attitude will significantly influence the use of the RFID integrated systems in libraries.*

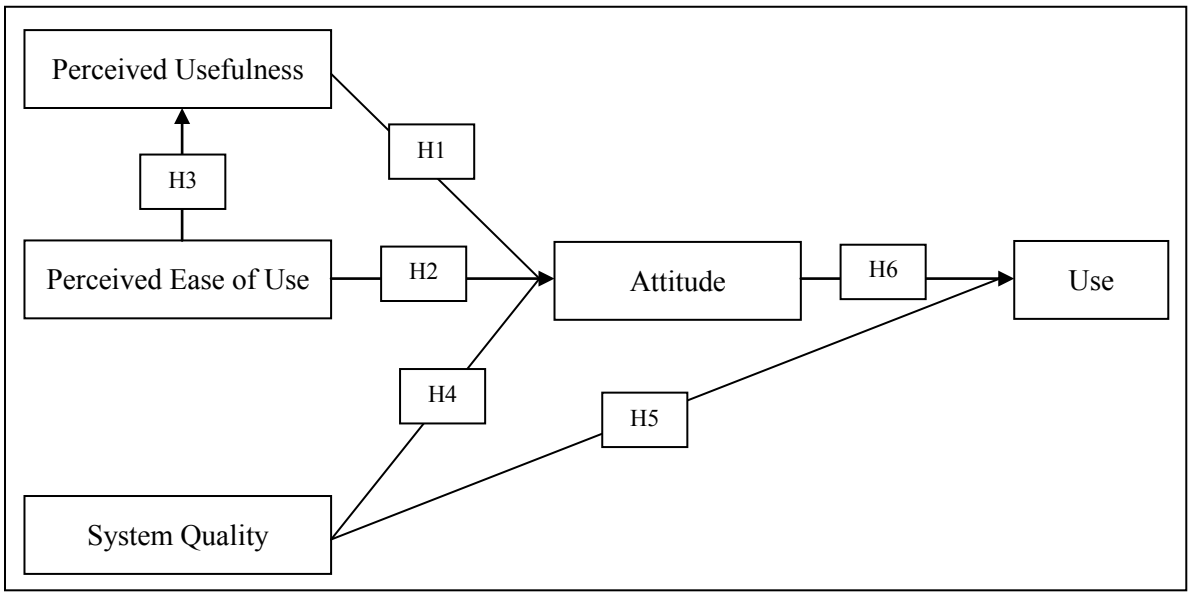

Figure 1. Extended TAM Model for examining the use of RFID integrated systems in Libraries

4. Research Method

A survey based approach was adopted for this study, whereby online questionnaires were circulated amongst the target respondents to examine the adoption of the RFID integrated systems in libraries. The questionnaires were designed to channelize the research relevant information from the respondents to the researcher for understanding the use of this technology in the library context.

4.1 Survey Instrument

The targeted items for the quantitative research in this context were the characteristics specific to the students' take on the RFID integrated services at the chosen library for this study. In the library services context, this survey targeted the university students to examine (i) their usage habits with respect to the RFID integrated services (ii) the frequency of their usage of these services (iii) the challenges faced while using these services, and also the benefits garnered (iv) their preferences and (v) their awareness of the existence and usage of these RFID enabled services. The questionnaires comprised of 17 questions in total, all of which were designed to be multiple choice questions, aimed at investigating the respondent perceptions. The respondents were required to rate each question/item on a five point Likert Scale (Hui and Triandis, 1989), where 5- Strongly Agree; 4- Agree; 3- Neither Agree nor Disagree; 2- Disagree; 1- Strongly Disagree. These items were being measured against five constructs in total. Each construct had a specific number of items to its account. Five questions were aimed at deriving the demographic information which has been elaborated in section 5. The remaining 11 questions were items mapped against the different constructs in the manner illustrated in table 3.

< Table 3 Here>

4.2 Pilot Study

Post the completion of designing the survey instrument, and prior the full out of the questionnaires to the intended larger population, a pilot study was arranged and carried out to ensure the understandability and ease aspects of the questionnaires from the respondents' perspective. The pilot was conducted with five respondents/students and it was made sure that the students across different study programs in the university were involved. At the end of the pilot test, it was revealed that the

respondents found the survey simple and easy to understand, and at the same time quicker to complete in terms of the time needed for completing the survey. Very few and minor suggestions came in, which were effectively addressed and incorporated in the final edition of the questionnaire.

4.3 Data Collection

This survey was carried out in 2010 at a targeted library in the United Kingdom. The students of this library, who were in effect the primary users of the RFID integrated services, were thought of as the appropriate respondent-population for this research. The aim was to measure the attitude of the respondents towards these RFID services, and as a consequence the actual usage of this technology. Given the size of the university, the *questionnaire based survey* approach seemed most appropriate for data collection purposes. It was therefore essential to circulate the questionnaires amongst all students who used these library services. The library staff was thus contacted, and they then e-mailed the online survey (in the mid of July 2010) to all students at the university requesting the interested ones to participate in this survey. The library staff took responsibility of circulating the survey. The total size of the respondent population was not known since the survey was randomly emailed to the students by the library staff and they chose not to disclose the mailing list to us, neither did they share the number of targeted students. The students were requested to complete the questionnaires within a 15-day period. A total of 197 fully completed questionnaires were received within those 15 days, which were considered to be adequate number of responses from the analysis purposes. Upon reviewing, it was found that 16 of these 197 questionnaires were returned incomplete, and in the interest of data accuracy and results reliability, it was decided to eliminate these 16 incomplete questionnaires. Doing so left 181 usable and valid responses that would be subjected to the SPSS analysis.

The SPSS 16.0 data analysis software was then used to generate – the frequency test results for the demographic characteristics, reliability test results to confirm the internal consistency of the used items, descriptive test results for all of the included items, and lastly the regression tests results to the test the proposed hypotheses for this study.

5. Findings

5.1 Demographics

Table 4 is a presentation of the demographics for the respondents of this survey. The accumulated information here has been arranged along respondents' – age, gender, educational level, frequency of library visits, and awareness of RFID integrated systems.

<Table 4 Here>

5.2 Reliability Test

The reliability test was undertaken for measuring the internal consistency of the survey items for each of the shortlisted construct for this study (table 5). Hinton et al. (2004) recognized four levels of reliability in terms of the Cronbach's alpha values, which were - (a) 0.90 and above representing excellent reliability (b) 0.70-0.90 representing high reliability (c) 0.50-0.70 representing moderate reliability and (iv) 0.50 and below representing low reliability. As shown in table 5, all five constructs showcased high reliability, indicating a relatively higher internal consistency amongst the items for all five constructs.

<Table 5 Here>

5.3 Descriptive Statistics

The descriptive statistics for all of the shortlisted constructs for this study have been listed against their means and standard deviations in table 6. It is clear from the table that *use* has the highest average mean value of 4.51 out of all the five listed constructs. This construct is then followed by *perceived ease of use, perceived usefulness, attitude,* and *system quality* in the same order.

< Table 6 Here>

5.4 Regression Analyses

According to Draper and Smith (1998), linear regression analysis gives an estimate of the linear equation coefficients involving one or more independent variables resulting in predictions of the value of the targeted dependent variable. In line with the proposed conceptual model (figure 1), three rounds of regression analyses were undertaken under this research for all 181 valid cases, which have been detailed in the remaining parts of this section.

5.5 Regression Analysis I: The influences of perceived usefulness, perceived ease of use, and system quality on attitude

The first regression run had three independent constructs – *perceived usefulness, perceived ease of use, and system quality* being regressed against user *attitudes* towards the RFID integrated services in the library context. The resultant model was: (F (3, 181) =93.595, p=000). The *adjusted R square* value was 0.596. Out of the three predictor variables, perceived usefulness (β=0.523, p=0.000) and system quality (β=0.294, p=0.000) reported significant influences on the library users' attitudes towards the RFID integrated systems. As evident from table 7, perceived ease of use was the only attribute reporting a non-significant influence on attitude.

<Table 7 Here>

5.6 Regression Analysis II: The influence of perceived ease of use on perceived usefulness

The second round of regression was run for examining the influence of perceived ease of use on the perceived usefulness of the RFID integrated library systems. As the findings have it in table 8, the resultant model (F (1, 181) =310.302, p=000) was with an *adjusted R square* value of 0.619, and a significant and positive effect of ease of use (β=0.788, p=0.000) on the perceived usefulness of the RFID systems.

<Table 8 Here>

5.7 Regression Analysis III: The influences of attitude and system quality on use

The third and last round of regression was run for the effects of *attitude* and *system quality* on the actual use of the RFID integrated library services. The resultant model was: (F (2, 181) =55.680, p=000). The *adjusted R square* value was 0.365. Both the predictor variables, system quality (β=0.328, p=0.000) and attitude (β=0.338, p=0.000) reported significant influences on the actual use of the RFID integrated systems (table 9).

<Table 9 Here>

5.8 Multicollinearity Test

Multicollinearity test was also undertaken for this study, and as seen in tables 7, 8 and 9, the results from this test have been documented under the Collinearity statistics columns. The VIF values for all three rounds of regression analyses showed values varying between 1 and 3.24. According to past studies, any and all values below 10 are favorable values for this test (Brace et al., 2003; Dwivedi et al., 2009). All values for this study are much lower than the maximum allowed value of 10, thus suggesting that attributes used in this study do not suffer from the multicollinearity problem. This in

effect also implies that the reported variances explained by these variables are most likely the reflection of the true situation (Brace et al., 2003; Dwivedi et al. 2009).

6. Discussions

6.1 Hypotheses Testing

A total of six research hypotheses (section 3, figure 1) were tested to examine whether the independent variables in this study had significant influences on the different dependent variables listed for this study. Five of the six hypotheses were supported by the gathered data (tables 7-9), in effect suggesting that all the independent variables, except perceived ease of use significantly influenced the dependent variables of this study (perceived usefulness, attitude, and use). The hypothesis proposed for testing the effect of ease of use on user attitudes (H2) failed, with the data not supporting the posited influence (tables 7), a detailed explanation of which will be provided in the remaining paragraphs of this section.

Hypothesis 1 was proven right for this study, whereby the perceived usefulness of the RFID integrated systems in the libraries positively influenced the user attitudes towards its use. This behavior of perceived usefulness has been widely supported across different technologies in the existing literature. For instance – a study on adoption of web technologies by Ajjan and Hartshorne (2008), study on the technology acceptance by Agarwal and Karahanna (1998), a study on adoption of online shopping by Vijayasarathy, (2004), a study on adoption of B2C e-commerce by Crespo and Rodriguez (2008), and many others were all found to be reporting significant influences of perceived usefulness on the attitude of the consumers towards the use of the considered innovations.

The relationship between perceived ease of use and usefulness has also been explored and supported by many past studies. Loiacono et al. (2007) develop a WebQual instrument by combining TRA and TAM for consumer evaluation of websites, and find ease of use to significantly influence both usefulness and use intentions of consumers. Yang and Choi (2001) revisit TAM to test the robustness of the model for different IS contexts; they conclude that perceived ease of use significantly predicts the usefulness of the system. Crespo and Rodriguez (2008) use TAM attributes alongside other attributes in an e-commerce acceptance study, and also find for ease of use to have a positive effect on the perceived usefulness. Hu et al. (2003) in their longitudinal study on technology acceptance find perceived ease of use having a positive effect on the perceived usefulness. Kim et al (2009) use TAM variables to study IT acceptance in the internal audit profession and find for perceived ease of use to significantly and positively impact the perceived usefulness. All these findings were in line with the findings from this study, whereby the proposed hypothesis 3 was proven valid and true. On the other hand, hypothesis 2 failed to fall in agreement with the past studies. As shown in table 7, this attribute was a non-significant predictor of use attitude. Many past studies have otherwise reported a significant effect of ease of use on attitude (Ajjan and Hartshorn, 2008; Vijayasarathy, 2004; Lin, 2008). Given the fact that today's youth are becoming increasingly technology compatible, in that, the tech savvy generation these days is very comfortable with experimenting new technologies; they also very easily adapt and learn the new products being made available in the market today. The RFID integrated kiosks at the libraries make book issue/renewal/return very simple and quick, in that, simply placing the books on the RFID kiosks takes care of all the aforementioned activities. Considering how simple it is to interact with these RFID integrated library systems, the students may have not found the issue of ease of use of any importance here, and hence may be the non-significance for this attribute in the library context.

Similarly, a good number of past studies have supported the appropriateness of the system quality construct in explaining the attitude and actual use of an innovative technology. System quality was seen to be successfully explaining the user attitude and actual use of various new technologies across various studies, for instance - the knowledge management systems study by Wu and Wang (2006), the ubiquitous computing study by Kim et al. (2009), the Greek taxation information system study by Floropoulos et al. (2010) and others. In addition, Petter et al. (2008) identified 14 studies that reported

significant effects of this attribute on system use. Then there were also Petter and McLean (2009), who in their meta-analysis of nine studies showed that all of the nine studies identified system quality to be a strong predictor of both user attitude and actual use. In the RFID context, the importance of this attribute has been recommended by McGinity (2004) and Gunther and Spiekermann (2005). The findings from this study are therefore in agreement with the past literature regarding the behavior of this attribute, thus proving hypotheses 4 and 5 true. It can thereby be concluded that the quality of RFID integrated systems is an important factor for determining the user attitudes, and in turn the actual use of those systems.

Finally, hypothesis 6 was also found to be fully supported by the gathered data. This finding is also completely in agreement with the past studies that have reported a positive and significant impact of user attitude on the actual use of an innovation. To exemplify a few, technology acceptance study by Agarwal and Karahanna (1998), and employee behavior study by Huang and Chuang (2007) have all reported its significant influence on actual use.

6.2 Validating the Conceptual Model

Figure 2 is an illustration of the validated conceptual model (as proposed in section 3) for the user attitude towards the RFID integrated library systems, and their actual use. As can been seen in Figure 2 the strong lines from *perceived usefulness* and *systems quality* towards *attitude*, from *perceived ease of use* towards *perceived usefulness*, and from *system quality* and *attitude* towards *use* are all representing the significant relationshipships between those attributes. On the other hand, the dotted line from *perceived ease of use* towards *attitude* is representative of the non-significant impact of this attribute on the user attitude.

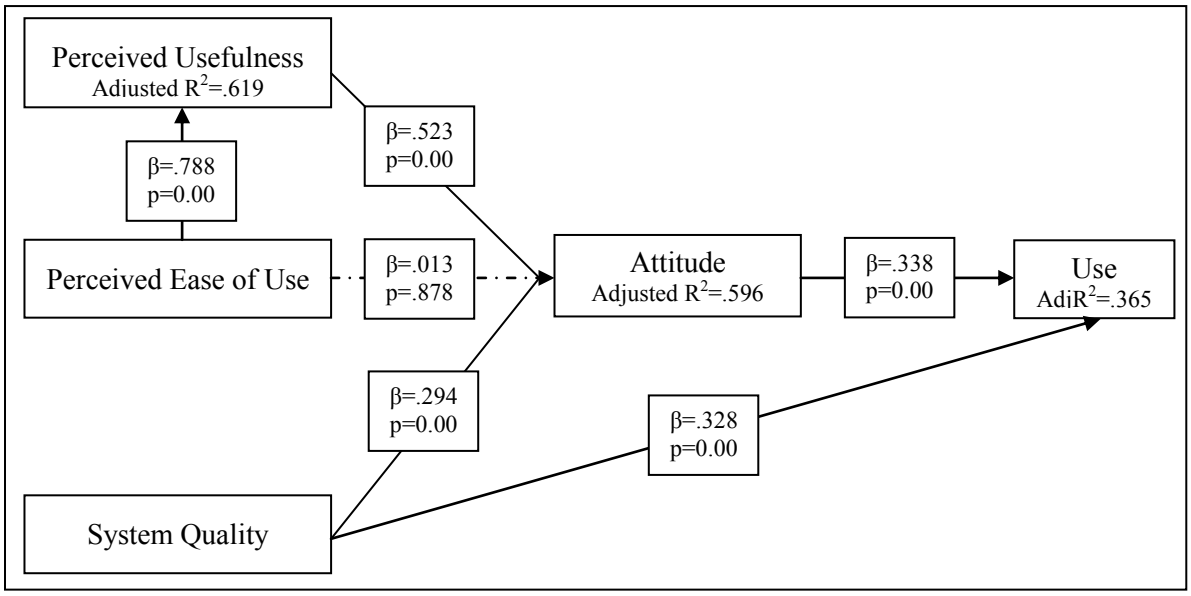

Figure 2. Validated Conceptual Model for examining the use of RFID integrated systems in Libraries

In terms of the model performance, the adjusted R-square values for all the three dependent variables were found to be comparable with the previous studies that have used these attributes in their empirical examinations. Comparing the R^2 values for perceived usefulness with the former studies (Aubert and Hamel, 2001; Kishore and McLean, 2007; Shih, 2008) revealed that the value reported by our study was comparable and in some cases, even higher than the R^2 values reported by the earlier studies. Thus, the variance for this attribute was well explained by the validated model. While a few studies were found reporting comparable R^2 values for attitude as a dependent variable (Lee and Kozar, 2008; Crespo and Rodriguez, 2008; Agarwal and Prasad, 2000), others were found showing a higher R^2 values than that reported in this study, that is higher than the value of .596 (Ajjan and Hartshorme, 2008, Huang and Chuang, 2007; Shih and Fang, 2004). Therfore, it can be concluded that the variance for this attribute, if not very well, was fairly well explained by this study. Another handful

of studies (Gerpott, 2011; Rai et al., 2002; Shih and Fang, 2004) reported adjusted R^2 values for use as a dependent variable lesser than the value of .36 reported by this study, indicating that this model delivers a satisfactory level of performace, in terms of the explained variance.

6.3 Research Contributions and Practical Implications

The findings from this study are theoretical contributions across two lines of research – one, this study contributes to the existing literature on the TAM Model, and two it adds to the existing literature on the RFID integrated systems in the libraries. By the authors' best knowledge there is very limited, rather minimalistic literature available on the empirical examination of the attitude towards, and the actual use of such the RFID systems, using the variables from the extended TAM model. Therefore, the findings from this study contribute in a way that enriches the existing knowledge in this particular theoretical paradigm by adding additional insights to the findings from the past studies (Floropoulos et al., 2010; Kim et al., 2009; Lopez-Nicolas et al., 2008; Rai et al., 2002; Wu and Wang, 2006; Yu et al., 2005).

In addition, Irani et al. (2010) had argued that the academic efforts of the RFID researchers have remained majorly concentrated on the examination of the technological issues; they further recommended that the researchers should now being investing efforts towards the exploration of the factors that influence the adoption of the RFID integrated systems at both, the individual and the organizational levels. The findings from this study are therefore a literary contribution on the individual and organization level adoption of the RFID integrated systems, as an increment over the already existing findings extended by the previous studies in this field of literature (Brown and Russel, 2007; Pramatari and Theotokis, 2009; Rothensee and Spiekermann, 2008).

As for the practical implications, the libraries that plan to integrate RFID in the library systems, specifically at the self-issue/return terminals, should essentially concentrate focus on system quality aspect, such as that of the ease of use and the associated response time whilst deploying such systems. The library users tend to avoid the manually managed service desk to jump the long queues in the hope of saving their time. Given this fact, if the RFID integrated self-issue/return terminals turn out to be complicated to use, or take longer to process requests it may result in adversely affecting the user experience, thereby negatively influencing the user attitudes towards the use of such terminals, having a bad impact on the second time/repeated use of these RFID terminals. Thus, during the design stage of such systems, the active involvement of the actual users of this system must be encouraged in order to understand their use and navigation of the system, and assess their comfort level with the interface. The findings also indicate that the ease of using these RFID systems positively influences the users' perceptions on the usefulness of the system, which in turn was seen to have a significant influence on the users' attitudes. Therefore, care should be taken to keep these terminals fairly easy to use and understand. This user-friendliness of these systems will make these terminals appear more beneficial to the library users, in that, they will be more attracted towards these terminals in comparison to the service desks, thereby increasing the use rates of these automated terminals.

In addition, the libraries newly introducing these terminals, and also at the start of a new academic year, should employ staff near these terminals for dedicated assistance to show the users how to use these systems over the initial few weeks. This will increase user awareness of the RFID integrated systems, and also attract more users. Attitude was also found to be positively and significantly impacting the actual use, which is why the library staff should encourage the library users to use these systems, and also work on familiarizing them with its use helping them form positive intentions that will, in turn, increase the overall acceptance of such RFID terminals at the libraries.

The findings under section 5.1, in table 4 showed that only 5.5% of the active library users knew all about RFID. This emphasizes the need to invest efforts in keeping the library users well informed about the introduced technology upgrades. The libraries should make available all the basic information needed to effectively garner the benefits of these installed RFID terminals. By simple logic, more awareness is expected to attract more users, all contributing towards an increased use rate.

7. Conclusions

This study is an attempt to understand the impact of a set of chosen innovation-attributes on the attitude towards the use of the RFID systems, and the actual use of those RFID integrated systems in libraries. Some of the key conclusions from this study have been summarized herewith - The literature review revealed that RFID is the most sought-after modern day implementation in the library context (Ayre, 2005; Coyle, 2005; Engel, 2006; Hicks, 1999). Good system quality will contribute towards establishing positive user attitudes, and help achieve higher usage of the RFID integrated systems in libraries. Whilst ease of was seen having a significant positive influence on the perceived usefulness of such systems, it had no significant influence over the user attitudes. This behavior is likely in cases where the library users are the tech-savvy youth that mostly have no problems in learning to use such automated/upgraded systems making the measurement of this attribute irrelevant in such contexts. Perceived usefulness positively influences user attitudes, therefore it becomes important to educate the target users on the benefits of using such systems to help them form positive intentions about the use of such systems. Attitude towards the system had a significant postive influence on its use. Thus, a contributory environment is to be established during new system implementation in order to enage the users with the new system being introduced. In asking the respondents about their use of the self issue/return terminals, most of them responded that their use of these terminals was frequent, thus leading to the final conclusion that the users preferred the RFID integrated automated terminals to the man-assited service desks for issuing and returning books at the library.

7.1 Limitations and Directions for Future Research

Moving on to the limitations of this study, in targeting the respondents for this study, only students utilizing the RFID integrated terminals at one UK university were targeted. In totality, RFID was integrated in various other management systems within that library, whose active users were the other staff and faculty members of that university. As a direction for future research, this other user population consisting of all active users in that library need to be targeted to achieve a more in-depth and fuller view of the use of these RFID systems in libraries. In addition, the inclusion of all active users (students, staff, and faculty members) will result in an increase in the number of respondents, in turn increasing the survey response rate, which will thereby increase the strength of the survey results.

The non-probability sampling of the respondents, whereby the survey was circulated to all students, may have introduced a self-selection bias. That is, it may be that only the frequent users of these RFID terminals, or those interested in this particular technology may have participated in the survey. Given that the aim of this survey was the examination of the attitude and actual use of the RFID terminals, these self chosen frequent users of these terminals proved to be the good set of respondents for this study, and it is thus unlikely for this particular aspect to have had a significant effect on the findings and results presented by this study. However, if the survey was exclusively aiming an examination of the adoption of this new system, then this would have had an adverse effect due to the reduced number of non-adopters of this technology having participated in the survey. The results of this survey are to a certain extent deprived of the perceptions of the non-adopter population, making the findings biased with the adopter population. Therefore, the future studies aiming investigations at the adoption of this system need to carefully employ the probability sampling approach to avoid the self-selection bias.

Ease of use, which was found to be non-significant, may have something to do with the instrument or the respondent-sample, and it may turn out to be that, had the sample been more diverse and selection-bias free, the non-adopters may have had different opinions. It may also be that this attribute is more relevant during the early stages of implementing these RFID integrated systems, which is why the future research should further refine, develop and then use the ease of use construct to examine the its role for determining the user attitude towards the use of the RFID integrated library systems.

For measuring perceptions on perceived usefulness, perceived ease of use, system quality, attitude, and use, a five-point Likert scale was put in use. Although five-point scales have been successfully used in existing research (for example, Kim et al., 2009), there remains a concern that the five-point scale proves to be less balanced than the seven-point Likert scale. Being in line with the wide ongoing academic debate on this topic, the future researchers may want to consider using the seven-point Likert scale instead of the five-point one.

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Benefits/ Applications	**Airlines**	**Healthcare**	**Library services**	**Retail**	**Warehouse Management**
Automation	O'Connor (2005)		Ayre (2004)	Bose et al. (2009)	Wang et al. (2010)
Eliminates Human Error	Ferrer et al. (2010)		Yu (2008)	Wen (2010)	
Capacity Expansion			Engel (2006)		Wang et al. (2010)
Cost Effective	Ferrer et al. (2010)		Boss (2006)		
Low Maintenance			Yu (2007)		
Self Service			Kern (2004)		
Customer Satisfaction			Coyle (2005)	Han et al. (2007)	

Simultaneous multiple tags communication			Molnar and Wagner (2004)	Huang et al. (2007)	Adenso-Diaz and Gascón (1999)
Cycle Time Reduction			Coyle (2005)		Adenso-Diaz and Gascón (1999)
Information Sharing	O'Connor (2005)	Lee et al. (2007)	Kern (2004)	Kim and Chong (2007)	
Inventory Tracking		Chen et al. (2010)	Bansode and Desale (2009)	Gaukler et al. (2007)	Wang et al. (2010)
Longer Lifetime			Yu (2007)		
No line of sight required			Coyle (2005)	Deyle et al. (2010)	
Safety		Lee et al. (2007)			
Reduces theft/ counterfeiting			Hicks (1999)	Herianto et al. (2008)	

Table 1. The RFID Domains: Applications and Benefits Mapping (Source: Adapted from Dwivedi et al., 2013)

Constructs	Definitions and Proposed Relationships	Source
Perceived usefulness	Refers to the relative advantage of using a new system over the already existing system, which will positively persuade consumer attitude towards the use of the RFID integrated systems	Angeles (2007), Berthold et al. (2005); Davis (1989); Katz and Rice (2009); Pramatari and Theotokis (2009); Wang et al. (2006)
Perceived Ease of Use	Refers to ease of using a system without much mental effort, which will positively influence the attitude and perceived usefulness of the RFID integrated systems	Davis (1989); Eckfeldt (2005); Pramatari and Theotokis (2009); Rothensee and Spiekermann (2008)
System Quality	Refers to desirable characteristics of an information system, which will positively influence the attitude and use of RFID integrated systems.	Delone and Mclean, 2003; Gunther and Spiekermann (2005); McGinity (2004); Pramatari and Theotokis (2009); Resatsch *et al*. (2008); Urbach and Muller, (2011)
Attitude	Attitude towards any technology will positively influence the use of that technology.	Angeles (2007), Berthold et al. (2005); Katz and Rice (2009); Pramatari and Theotokis (2009); Rothensee and Spiekermann (2008)
Use	Use is a measure of the spread of the technology.	Delone and Mclean, 2003; Gedenk *et al*. (2007); Gunther and Spiekermann (2005); Hossain and Prybutok (2008); McGinity (2004); Pramatari and Theotokis (2009); Resatsch *et al*. (2008); Urbach and Muller, (2011)

Table 2. Definitions and proposed attribute-relationships for examining the use of RFID integrated systems in Libraries

Constructs	Survey Questions/Items (Sources: Delone and Mclean 1993;2003;2004; Floropoulos et al., 2010; Kim et al., 2009)
Perceived Usefulness	PU1: The library's self return/issue terminals are very helpful. PU2: The library's self return/issue terminals make book loan/issue convenient for me. PU3: The library's self return/issue terminals make me more efficient at the library.

Perceived Ease of Use	EU1: I find it easy to use self return/issue terminals at the library. EU2: I can easily understand and use self return/issue terminals.
System Quality	SYQ1: Library's self-issue/return terminals are user friendly. SYQ2: The response time of the self-issue/return terminals is acceptable.
Attitude	A1: Using library's self-issue/return terminals is a good idea. A2: I like the idea of using library's self-issue/return terminals. A3: Using library's self-issue/return terminals is more pleasant.
Use	U1: I use self issue terminal to issue books at the library. U2: I use self return terminal to return issued books.

Table 3. Constructs-Items Mapping

Variable	**Group**	**Frequency**	**%**
Age	18-24	128	70.7
	25-34	36	19.9
	35-44	8	4.4
	45-54	7	3.9
	55+	2	1.1
	Total	181	100
Gender	Female	115	63.5
	Male	66	36.5
	Total	181	100
Education	Postgraduate-Research	28	15.5
	Postgraduate-Taught	38	21.0
	Undergraduate	111	61.3
	Others	4	2.2
	Total	181	100
Frquency of Library Visit	Many times a week	35	19.3
	Once a week	35	19.3
	Once in 2 weeks	49	27.1
	Once a month	51	28.2
	Others	11	6.1
	Total	181	100
RFID Awareness	I am not familiar with it at all	102	56.4
	I have only heard about it	41	22.7
	I have some knowledge of what it is	28	15.5
	I know all about RFID	10	5.5
	Total	181	100

Table 4. Survey Respondents' Demographic Characteristics

Constructs	**Sample**	**Items**	**Cronbach's Alpha (α)**	**Reliability Type**
Perceived Usefulness	181	3	0.878	High
Perceived Ease of Use	181	2	0.894	High
System Quality	181	2	0.839	High
Attitude	181	3	0.745	High
Use	181	2	0.888	High

Table 5. Reliability Test Results

Constructs	**N**	**n**	**Mean**	**Std Deviation**
Use	181	2	4.51	0.841
Perceived Ease of Use	181	2	4.32	0.959
Perceived Usefulness	181	3	4.25	0.882

Attitude	181	3	4.10	0.842
System Quality	181	2	4.05	0.866
Legend: N=Number of Usable Responses; n=Number of Items				

Table 6. Descriptive Statistics

Model		Standardized Coefficients	t	Sig.	Collinearity Statistics		Hypotheses Support
		Beta			Tolerance	VIF	
	(Constant)		3.259	.001			
	Perc Usefulness	.523	6.726	.000	.355	2.820	H1: Supported
	Ease of Use	.013	.153	.878	.309	3.241	H2: Not Supported
	System Quality	.294	3.760	.000	.352	2.841	H4: Supported
Adjusted R Square		0.596					
F		93.595					
Significance		0.000					

Table 7. Regression Analysis 1: Examining influences of independent variables on user attitude

Model		Standardized Coefficients	t	Sig.	Collinearity Statistics		Hypotheses Support
		Beta			Tolerance	VIF	
	(Constant)		4.687	.000			
	Ease of Use	.788	17.615	.000	1.000	1.000	H3: Supported
Adjusted R Square		0.619					
F		310.302					
Significance		0.000					

Table 8. Regression Analysis 2: Examining influence of independent variables on perceived usefulness

Model		Standardized Coefficients	t	Sig.	Collinearity Statistics		Hypotheses Support
		Beta			Tolerance	VIF	
	(Constant)		7.795	.000			
	System Quality	.328	4.186	.000	.543	1.843	H5: Supported
	Attitude	.338	4.306	.000	.543	1.843	H6: Supported
Adjusted R Square		0.365					
F		55.680					
Significance		0.000					

Table 9. Regression Analysis 3: Examining influences of independent variables on use