An Integrative Model of Consumer’s Adoption of RFID Credit Card Service

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Abstract
This research coalesces three different approaches to consumer’s adoption of new technology-based service into an integrative model. We use the basic framework of TAM and supplement technology readiness and perceived risk to the model to better address the consumer adoption context. The model is tested with data from 343 web surveys regarding RFID credit card adoption. Results show that technology readiness and perceived risk add a significant set of predictors to behavioral intentions while perceived usefulness remain the primary driver of behavioral intentions.

1. Introduction
A service innovation is successful only when it is accepted by the market [1]. Yet various factors can exert influences on the adoption of a new service. Thus, for service managers, understanding what affect the attitude and intentions of target customers is vital in ensuring the success of a newly designed service. When a new service is based on new technologies, the story gets even more complicated as the consumers have to both digest the service itself, and the technology involved. Consumers may readily embrace services with the latest technology, or they may balk with concerns and reservation of the new technology. The RFID credit card adoption in Taiwan is a case in point. Two years after Visa’s launch of payWave in 2005, Visa’s RFID contactless credit card in Taiwan, after many campaigns and promotions, the total card issuance reached 1.37 million in 2007, only 6% of the 16.69 million non-contactless Visa credit card issuance in Taiwan. What are the factors that influence consumer attitude and intentions with new technology-based service? This is the question that we set out to explore with this research.

Researchers have approached the question of users’ adoption of new technology from different perspectives, and these approaches are generally applicable to new technology-based services as well[2-3]. Originating from social psychology, the Theory of Reasoned Action (TRA)[4], the Theory of Planned Behavior (TPB)[5-6], and the Technology Acceptance Model (TAM)[7-8] explore users’ behavior intentions from the attitudinal and cognitive perception dimensions. Another camp of research stems from the Diffusion of Innovations (DOI) theory[9], which indentifies a variety of factors as determinants of the adoption and usage of innovation, including the characteristics of the technology, the characteristics of users, and contextual environment. In the same vein, scholars propose that it is individual differences in technology propensity that dictates whether the user will embrace new technologies([10-13]. In addition, a separate stream of market researchers have argued the importance of perceived risk in consumer decision making[14-16]. Later research on ecommerce adoption flourishes with perceived risk as a major determinant of adoption prediction [17-20]

With each line of research developing and evolving in its own direction, the awareness that an integrated model would provide a holistic view of consumer technology adoption and acceptance has been raised and early initiatives have been attempted [17-18, 21]. Building on these endeavors, this study proposes a comprehensive model that integrates the major streams of research to account for consumer’s adoption of new technologies under the RFID credit card context and examines the relatively contributions of each component. First we review extant research, then we test our hypotheses with data collected from web surveys. Finally, theoretical and practical implications are offered.

2. RFID contactless credit card
Radio-frequency identification (RFID) is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves. Contactless cards using RFID
technology eliminate the need for purchasers to sign and swipe with the more traditional version of credit cards. Instead, the buyer just waves the card in front of a scanner. Contactless credit cards store data on a special chip embedded in the card's plastic. The data is transmitted from the chip to the credit card reader at the checkout counter via RFID. Contactless cards also still have the magnetic stripe on the back so it is compatible with more traditional payment readers.

Contactless Credit Cards boast the advantages of faster, more convenient transaction experiences. However, privacy becomes a concern as media reports that personal data is more exposed to risk of theft with the always-on and contactless feature of those cards. To address this concern, a number of RFID-specific “Privacy-Enhancing Technologies (PETS)” have been proposed. These technologies prevent the uncontrolled reading of transponders as well as the manipulation of information saved in them. The simplest protection from access to transponders by third parties is physical separation, by means of a metal net or a foil sheet. Other options include the use of jammer transmitters or so-called “blocker tags”, distance-based access control, and bug-safe anti-collision protocols[22].

3. Literature review

3.1 Technology acceptance model (TAM)

As an adaptation of the TRA and TPB, TAM [7-8] has been received as a “powerful and parsimonious way to represent the antecedents of system usage through beliefs about two factors: the perceived ease of use and the perceived usefulness of an information system” [23]. Perceived Usefulness (USF) is defined as “The prospective user’s subjective probability that using a specific application system will increase his or her job performance within an organizational context” [8]. Perceived Ease of Use (EOU) is defined as the “degree to which the prospective user expects the target system to be free of effort”. Empirical tests of TAM indicate that perceived usefulness is a strong determinant of behavioral intention, while perceived ease of use is a relatively weak determinant of intention[24].

Two caveats of TAM should be noted. First, TAM was originally conceptualized to be used within an organizational context [7], thus, modifications to its application in the consumer context may be needed. Second, following TRA and TPB, the original TAM postulates attitude as a mediating variable between the two determinants and behavioral intention. However, studies have demonstrated that without the attitude construct, the explanatory power of the model is equally good [8]. As a result, it has become a norm to exclude the attitude construct from TAM.

3.2 Diffusion of Innovations (DOI) and Technology Readiness Index (TRI)

One of the most cited books in social sciences, the Diffusion of Innovation describes five sets of factors as the determinants of innovation adoption and usage rate [9]. The first set encompasses characteristics of the technology (compatibility, complexity, relative advantage, trialability and observability); the second set concerns the innovation decision type (individual, group, or authoritative); the third and fourth set deal with channels via which the innovation is communicated and social system norms respectively. Finally, the influence of promotion personnel is noted as the fifth set. Together, these five sets of factors predict the adoption rate of a certain innovation. In addition, Rogers[9] categorizes people into five groups per their innovation adoption pattern: innovators, early adopters, early majority, late majority and laggards. Rogers depicts innovators as having some specific traits, for example, higher tolerance to uncertainty and risk, internal locus of control, higher self-efficacy etc. Rogers argue that personal characteristics, along with social-economical status and communication behavior, predict whether a person will be receptive of innovations.

Consistent with this school of thought, Parasuraman[11] proposes the Technology Readiness Index (TRI) to measure and predict an individual’s readiness to use new technology with four personality traits: Optimism (a positive view of technology and a belief that it offers people increased control, flexibility and efficiency in their lives); Innovativeness (a tendency to be a technologically pioneering and thought leader); Discomfort (a perceived lack of control over technology and a feeling of being overwhelmed by it) and Insecurity (distrust of technology and skepticism about its ability to work properly). Of the four dimensions consisting TRI, Optimism and innovativeness are positively related, while discomfort and insecurity are negatively related to use a new technology.

Current research differs as to whether technology readiness is a trait, or past experiences. Some researchers think of TR as primarily related to psychological traits [25]; while others maintain that TR is most linked to previous product experience and knowledge [26]. Parasuraman[11] defines TR construct as an overall state of mind resulting from a gestalt of mental enablers and inhibitors that
collectively determine a person’s predisposition to use new technologies. Therefore, the sources of the beliefs can stem from either personality, or past experiences. For example, one of the statements reads “You do not feel confident doing business with a place that can only be reached online”. A high score attributed to this item could be either that the person is cautious by nature, or that he or she had negative experiences dealing with online only stores that leads him or her to feel insecure in the future.

3.3 Perceived risk

Bauer[27] proposed that consumer behavior should be seen in the theoretical framework of risk taking. Risks arise due to uncertainties and thus perceived risk is commonly thought of as felt uncertainty regarding possible negative consequences of using a product or service. Cox and Rich[16]’s empirical study of consumers’ adoption of telephone shopping has shown that the nature and degree of risk perceived by the consumer, and the manner in which the consumer deals with perceived risk, are important determinants of decisions of whether to adopt the then novel shopping method. PR enters the technology adoption decision when circumstances of the decision create (a) feelings of uncertainty[28], (b) discomfort and/or anxiety[15], (c) conflict aroused in the consumer [29], (d) concern, (e) psychological discomfort[30], and (f) cognitive dissonance [31]. The dissonance arises from the evaluation of the product as having costs and benefits, risks and utility. Cunningham[32] typified perceived risk as having six dimensions — (1) performance, (2) financial, (3) opportunity/time, (4)safety, (5) social and (6) psychological loss. He also posited that all risk facets stem from performance risk. A rich stream of consumer behavior literature supports the usage of these risk facets to understand consumer product and service evaluations and purchases.

Similarly, in Ring and Van de Ven’s classification[33], risks are either technology-driven, and thus derived from the underlying infrastructure (environmental risks), or relational, resulting from the trading partner (behavioral risks).Consumers consciously and unconsciously perceive risk when evaluating products and services for purchase and/or adoption. Information systems adoption has been shown to create anxiety and discomfort for consumers and employees alike.

It should be noted that Perception of control was the key addition to the Theory of Reasoned Action (TRA) to arrive at the Theory of Planned Behavior (TPB). Perception of control was later incorporated into the extended TAM model as control has been shown to have an effect on key dependent variables such as intention and behavior in a variety of domains[34]. Lack of perceived control reflects the perception of uncertainty of the environment, and can thus be regarded as addressing the risk factor from another angle.

4. Research Model

As noted in the literature review part, The TAM model was originally developed to depict technology adoption in the work setting, thus may need modifications to fit the consumer context. One of the differences between work setting and consumer setting is the decision type involved. In work setting, decisions are typically made top-down, and end-users are mandated to accept the technology; while in the consumer context, more personal factors, for example, the consumer’s past experience and personality traits, may play a role. As Rogers noted[9], personality is a valid predictor of whether the consumer will be a innovator in adoption of new technology. Thus, we complement the TAM model with the TRI measuring an individual’s innovative propensity to accommodate the consumer technology adoption context. It should be noted that even though TAM is adapted from TRA, it is quite similar to DOI in that the TAM constructs, perceived usefulness, and perceived ease of use, are analogous to Rogers’ perceived relative advantage and perceived complexity[35]. Since perceived usefulness is a stronger determinant of behavioral intention, while perceived ease of use is a relatively weak determinant of intention [24], and since our research object, RFID credit card, involves minimum learning to use, we exclude the perceived ease of use construct in the model.

An important factor in consumer decision making: perceived risk, is included in the framework to complement the TAM model. Unlike the mandated system use at work, where risk and benefit considerations are out of scope for end user, in consumer’s adoption of technology, perceived risk becomes an important factor. The complexity of technology causes not only feelings of anxiety but also uncertainty[36], which lead to the perception of risk. In turn, perceived risk causes the potential adopter to devalue perceived usefulness, as well as adoption intentions.
Individual differences, including personality and demographic variables have been reported to account for information technology acceptance, however, they do not explicate the process by which acceptance is influenced [37]. Agarwal and Prasad [28] theorized the relationship between individual differences and IT acceptance to be mediated by the constructs of the technology acceptance model. In essence, individual differences are viewed as influencing an individual’s beliefs about an information technology innovation through social learning processes. Similarly, we argue that a person’s general technology readiness influences his or her beliefs or cognition about a specific information technology, which in turn determine his or her use intention with a proximal-distal approach. The terms “proximal” and “distal” indicate the theorized degree of immediate influence of a variable class on a person’s current attitudes. The term “distal” denotes those factors that are preexisting and general, thus being remote from current attitudes, intentions, and behavior. The term “proximal” denotes factors that are more immediate to behavior and situational specific, conceptualizing such factors as concomitant perceptions as being most proximal to current attitudes, intentions, and behavior. We hypothesize a causal sequence such that (a) the distal factors (i.e., general belief and personality represented by TRI) would lead to both proximal factors (i.e., specific cognition of risk and usefulness of a particular technology) and (b) the proximal factors would lead directly to use intentions. We reason that the more proximal the construct, the stronger should be its prediction of the use intention as behavior is primarily determined by the individual’s immediate perceptions and situational influences [38]. Thus, we have:

H1: Technology readiness positively affects use intention mediated through perceived usefulness

H2: Technology readiness positively affects use intention mediated through perceived risk

4.2 Technology readiness and use intention

According to TRA, a person's performance of a specified behavior is determined by his or her behavioral intention (BI) to perform the behavior, and BI is jointly determined by the person's attitude (A) and subjective norm (SN) concerning the behavior in question. Various studies have validated that people’s attitudes and beliefs can influence use intentions. Cowles [39] suggested the presence of distinct customer segments with differing perceptions about and acceptance of new technology. In a study of consumers’ evaluations of and intentions to use technology-based self-service options, Dabholkar [40] found that consumers varied in terms of their beliefs/feelings about the various options and that those beliefs/feelings were positively correlated with intentions to use. Thus, we propose that technology readiness exerts a direct influence on use intention.

Figure 1: An integrative model of consumer’s adoption of RFID credit card
but such influence would be attenuated with the mediating effects of perceived usefulness and perceived risk.

**H3:** Technology readiness positively affects use intention. However, the direct effect size is smaller than the total mediated effects.

### 4.3 Perceived risk and perceived usefulness

Consumers consciously and unconsciously perceive risk when evaluating products and services for purchase and/or adoption [27]. Information systems adoption has long been known to create anxiety and discomfort for consumers and employees [36]. The combination of uncertainty (probability of loss) and danger (cost of loss) that make up perceived risk have been shown to inhibit product evaluation (e.g. perceived usefulness) and adoption[15]. Therefore,

**H4:** Perceived risk is negatively related to perceived usefulness.

### 5. Methodology and Measurement

We chose RFID contactless credit card as our subject of study. Web-based surveys were posted in Taiwan’s major online credit card forums and discussion boards in April 2008. Questions ask about participants’ perception of contactless RFID credit cards and future use intention. We target credit card users that are at least 18 years of age. Participants are asked to leave an email address for a lottery for a small prize. A total of 373 questionnaires are returned. The final survey produced 343 usable responses, after accounting for incomplete responses. The sample consists of slightly more male(51.6%) than female(48.4%). The majority of the sample are between 21 and 30 years of age (89.5%). 78% of them have 1-3 credit cards.

Constructs were measured with 5-point Likert scales. Perceived usefulness was adapted from Davis[7], and two items concerning job performance and productivity were deleted. Perceived risk was measured with Stone et al. [41]’s risk dimensions. Because physical risk and time risk(actually one of the advantages of RFID credit card is that it saves processing time) were not relevant under this context, these two dimensions were not included. We measured technology readiness with Parasuraman [11]’s 36-item scale. Two items were used to measure behavior intention based on Venkatesh and Davis[24].

### 6. Analysis and Results

Of the 373 surveys returned, listwise deletion was performed. All deletions contain more than one missing values. Outliers have an inordinate effect on regression estimates[42] and can therefore undermine the assessment of correspondence. Hence, we screened our data with Mahalanobis’ D square and find inconsistent and illogical response patterns. Overall, this examination of the data result to a reduction to a final set of 343 usable responses.

Confirmatory factor analysis is performed as our preliminary analysis. Reliability gauged by composite reliability is examined. Composite reliability is a preferred alternative to Cronbach’s alpha as a measure of reliability because Cronbach’s alpha may over- or under-estimate scale reliability[43]. In an adequate model for exploratory purposes, composite reliabilities should be greater than 0.6[44] and greater than .70 for an adequate model for confirmatory purposes.. Because perceived risk consist of multiple dimensions each with their own measurements, scale scores were computed by averaging their respective raw scores and were used as reflective indicators of those two constructs.

We test our hypotheses with partial least squares (PLS) technique. PLS is similar to LISREL in that both structural relationships among latent variables and relationships between latent variables and observed variables may be modeled. However, PLS is better suited for exploratory analysis than LISREL. We chose PLS because our framework consists of an integrated model never tested before. As such, the research model is not based on “strong theory” and it would be more suitable to test it under the PLS method.

Convergent validity is gauged by examining the average variance extracted(AVE). Items associated with a given construct should be greater than .50, indicating more than half of the variance is true score instead of error [45] . As table 3 indicates, most constructs exhibit high convergent validity and only TRI has a marginal value. Discriminant validity is estimated by comparing the construct correlations with the square root of AVE of the construct. In this method, the square root of AVE should be greater than the correlation between construct pairs[45-46]. Table 1 contains the construct correlations and on the diagonal the square root of AVE. It demonstrates that all of our constructs have good discriminant validity.
Table 1: Latent variable correlation matrix with square root of average variance extracted on the diagonal in bold.

<table>
<thead>
<tr>
<th>Construct</th>
<th>TRI</th>
<th>Perceived usefulness</th>
<th>Perceived risk</th>
<th>Behavioral intention</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRI</td>
<td>0.669</td>
<td>0.341</td>
<td>-0.367</td>
<td>0.48</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>0.341</td>
<td>0.903</td>
<td>-0.433</td>
<td>0.703</td>
</tr>
<tr>
<td>Perceived risk</td>
<td>-0.367</td>
<td>-0.433</td>
<td>0.763</td>
<td>-0.44</td>
</tr>
<tr>
<td>Behavioral intention</td>
<td>0.48</td>
<td>0.703</td>
<td>-0.44</td>
<td>0.968</td>
</tr>
</tbody>
</table>

The PLS estimation results for the structural model are summarized below in Figure 2. Because PLS does not generate an overall goodness-of-fit index, one primarily assesses validity by examining the R square and the structural paths, as one would with a regression model.

The findings support all our hypotheses. Specifically, technology readiness has a direct effect on use intention (coefficient 0.17). The direct effect, however, was much stronger in a separate model without the two moderators (coefficient 0.45), confirming the mediating effects of perceived usefulness and perceived risk. Together more than 50% of TRI’s effects were mediated through perceived usefulness and perceived risk, thus providing support for hypothesis 3. Perceived risk is negatively related to TRI, perceived usefulness, and behavioral intentions, as expected. Approximately 55.5% of the variance in behavioral intention is accounted for by the three constructs in the model. Surprisingly, perceived usefulness proves to be the single most important factor in behavioral intentions, with a strong coefficient of 0.60. It is also the mediator of both TRI and perceived risk to behavioral intentions, confirming that the TAM model is indeed a parsimonious and powerful framework to predict behavior intentions. The standardized path coefficients range from 0.12 to 0.60, with most paths exceeding the suggested minimum standard of significance at 0.20 [44]. Thus, the fit of the overall model is good.

Table 2: Construct loading and t-statistics

<table>
<thead>
<tr>
<th>Factors/indicators</th>
<th>Standardized loading</th>
<th>t-Value</th>
<th>Composite reliability</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRI:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>optimism</td>
<td>0.699</td>
<td>15.778</td>
<td>0.759</td>
<td>0.447</td>
</tr>
<tr>
<td>Innovation</td>
<td>0.809</td>
<td>27.133</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discomfort</td>
<td>0.598</td>
<td>7.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insecurity</td>
<td>0.537</td>
<td>6.762</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk:</td>
<td></td>
<td></td>
<td></td>
<td>0.843</td>
</tr>
<tr>
<td>Social risk</td>
<td>0.492</td>
<td>6.995</td>
<td>0.582</td>
<td></td>
</tr>
<tr>
<td>Financial risk</td>
<td>0.869</td>
<td>61.215</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance risk</td>
<td>0.805</td>
<td>36.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychological risk</td>
<td>0.827</td>
<td>46.936</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td></td>
<td>0.947</td>
<td>0.816</td>
<td></td>
</tr>
<tr>
<td>PU1</td>
<td>0.914</td>
<td>71.325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU2</td>
<td>0.919</td>
<td>73.599</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU3</td>
<td>0.916</td>
<td>75.912</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PU4</td>
<td>0.863</td>
<td>45.925</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral intention</td>
<td></td>
<td>0.968</td>
<td>0.937</td>
<td></td>
</tr>
<tr>
<td>BI1</td>
<td>0.968</td>
<td>168.846</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI2</td>
<td>0.968</td>
<td>168.846</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. Conclusion and discussion

This study aims to provide an integrated framework for understanding consumer’s adoption of new technology. Two new elements were added to the TAM framework, namely, perceived risk and technology readiness, addressing the risk-taking nature of consumer behavior and individual propensity for innovation. The framework employs a distal-proximal approach to comprehensively capture trait and experience related factors along with contextual factors. Results show that the integrated model has added a significant set of predictors to behavioral intention by integrating the three streams of theory into one. This model also contributes to theory by adjusting the TAM framework with the consumer context, making the originally for-work model relevant for consumer technology adoption.

Our results provide important implications for managers. First, perceived usefulness proves to be a primary determinant of behavioral intentions, mediating the effects of perceived risk and technology readiness. Thus, to promote adoption, the focus should still be on the usefulness of the product. A two sided approach should be deployed to enhance the usefulness perception, one emphasizing the benefits of the product, including but not limited to benefits of time saving, convenience, security, social recognition, performance improvements and etc; the other side of the usefulness perception calls for reducing the perception of risks by addressing concerns and issues that consumers may have. By decomposing perceived risks into several dimensions, this research helps managers to understand how to deal with negative perceptions that would lead to damaged usefulness perceptions. In general, social (does any aspect of my product cause the user to look silly in his/her peers’ eyes), time (does it take too much to learn to use and to actually use), financial (does it incur more cost than savings to the user), performance (does it really perform better), psychological (does any aspect of my product make people nervous) can be used as a basic framework to assess the potential issues. A close eye of the media coverage is also needed and any issues raised should be properly clarified to ensure the continuing acceptance of the new product.

Second, technology readiness has a direct positive impact on behavior intentions. Thus, for new services that are first perceived as risky or not very useful, a possible first group of customers come from those with the highest technology readiness. To attract those consumers, two aspects should be emphasized. First, the product incorporates the latest technology, and second, the product is innovative. As consumers with high technology readiness tend to try the latest technology and enjoy the challenges of new technology, addressing these two features would

Figure 2: Results
probably garner the very first crowd of users. However, in the long run, to win more users, the perceived usefulness and perceived risks aspects should ultimately be addressed.

Limitations of this research should be noted. Our data was collected from online forums and discussion groups of credit card users in Taiwan. Customers from a more diverse background, on a random sampling basis, would be preferred for better generalizability. Second, a longitudinal design that assess TRI, perceived risk, perceived usefulness and behavior intentions at different points in time is more appropriate and provide more insights. Future research can proceed in this direction. Last, to adapt the contactless credit card context, perceived ease of use is removed. Future research could test this framework under different context where perceived ease of use is relevant, thus providing a more comprehensive framework.

8. References


