Expert Systems with Applications 40 (2013) 5604–5620

Contents lists available at SciVerse ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Predicting the determinants of the NFC-enabled mobile credit card acceptance: A neural networks approach

Lai-Ying Leong [a], Teck-Soon Hew [b], Garry Wei-Han Tan [a], Keng-Boon Ooi [c,*]

[a] Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Kampar, Malaysia
[b] Faculty of Business and Accountancy, University of Malaya, Malaysia
[c] Chancellery Division, Linton University College, Malaysia

ARTICLE INFO

Keywords:
Near Field Communication (NFC)
Mobile credit card
Artificial neural networks
Mobile payment
Trust

ABSTRACT

The main aim of this study is to determine the factors influencing the adoption of Near Field Communication (NFC)-enabled mobile credit card, an innovation in contactless payment for the future generation. Constructs from psychological science, trust-based and behavioral control theories were incorporated into the parsimonious TAM. Using empirical data and Structural Equation Modeling-Artificial Neural Networks approach together with multi group analysis, the effects of social influence, personal innovativeness in information technology, trust, perceived financial cost, perceived usefulness and perceived ease of use were examined. The significance of indirect effects was examined using the bias-corrected percentile with two-tailed significance through bootstrapping. Gender, age, experience and usage were introduced as the moderator variables with industry being the control variable in the research model. The scarcity in studies regarding the moderating effects of these variables warranted the needs to further investigate their impacts. The mediating effect of perceived usefulness was examined using the Baron–Kenny's technique. The findings of this study have provided invaluable theoretical, methodological and managerial implications and will contribute to the decision making process by CEOs, managers, manufacturers and policy makers from the mobile manufacturing industry, businesses and financial institutions, mobile commerce, mobile telecommunication providers, mobile marketers, private or government practitioners and etc.

1. Introduction

With the advancement in short-range wireless technologies such as Near Field Communication (NFC), Bluetooth, Infrared Data Association (IrDA) and Radio Frequency Identification (RFID), consumers have been able to conduct payment "anytime" and "anywhere". A new form of payment has emerged through the integration of these technologies into the mobile phone whereby consumers just need to make payments via their own mobile phones. Known as mobile payment or m-payment, it is anticipated to become an essential application in mobile commerce. One form of m-payment that is gaining popularity is the mobile credit card or m-credit card using NFC-enabled mobile phones. Instead of using the traditional payment methods by cash, cheques or credit cards, mobile phones are widely used now for consumers to submit their payments for a variety of goods and services purchased (Shin, 2010). With m-credit card, consumers just need to 'wave' their mobile phones near a reader for payments to be done. In Malaysia, Maybank through the partnership with Maxis, Visa, Nokia and Touch'n Go has provided the facility for its customers to conduct m-payment using the Maxis FastTap service via the Maybankard Visa payWave Mobile. According to Stuart Tomlinson, "Malaysia was the first place in the world where Visa trialed its Visa payWave technology, so it is only fitting that it is now the first country in the world to offer Visa payWave on an NFC-enabled mobile phone on a commercial basis" (www.maxis.com.my, 2012, p. 1).

Various definitions have been given to m-payment. Dewan and Chen (2005, p. 4) defined m-payment as "making payments using mobile devices including wireless handsets, personal digital assistants (PDA), radio frequency (RF) devices, and NFC based devices". M-payment is also refer to as "payments for goods, services, and bills with a mobile device such as mobile phone, smart-phone, or PDA by taking advantage of wireless and other communication technologies" (Dahlberg, Mallat, Ondrus, & Zmijewska, 2008, p. 165). Besides that, m-payment may be referred to as "using mobile devices to make transactions such as pay bills and perform banking transactions" (Gerpott & Kornmeier, 2009, p. 1). According to Innopay (2012, p. 12), m-payment is defined as "a transfer of funds in return for a good or service, where a mobile phone is involved in

* Corresponding author. Tel.: +60 6 7587888.
E-mail addresses: lyennlly@gmail.com (L.-Y. Leong), hewtecksoon@gmail.com (T.-S. Hew), garrytanweihan@googlemail.com (G.W.-H. Tan), ooikengboon@gmail.com, kbooi@leg.edu.my (K.-B. Ooi).

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http://dx.doi.org/10.1016/j.eswa.2013.04.018

both the initiation and confirmation of the payment". In this study, we have adopted the definition by Ghezzi, Renga, Balocco, and Pescetto (2010, p. 4) who have summarized the previous authors' view as follows:

> "m-payment is a process in which at least one phase of the transaction is conducted using a mobile device (such as mobile phone, smartphone, PDA, or any wireless enabled device) capable of securely processing a financial transaction over a mobile network, or via various wireless technologies (Bluetooth, RFID, NFC, etc.)".

NFC-enabled mobile phones have enabled contactless payments in a vast variety of businesses with huge potential. It renders numerous benefits including quick purchasing of products and transferring of secure information by just touching devices and this is especially convenient in an environment where the volume of payments are high, for example in restaurants and large retailers. Such a wireless payment method has allowed consumers to eliminate the use of cash while offering the added benefits of user-friendliness and fast transaction speed. Furthermore, the NFC-enabled mobile phones may also read NFC tags that can host a diversity of content such as vouchers, videos, social media pages, competitions, travel information and etc. It also permits users to engage with conventional marketing campaigns and even download promotions and offers through SmartPosters that can be redeemable in-store through the use of the technology (Innopay, 2012). Other benefits of NFC-enable mobile phones include ease of use, simple communication setup and low power consumption (Madlmayr, Langer, Kantner, & Scharinger, 2008). Due to these benefits, the popularity of contactless payments can be seen from the 60,000 and more contactless terminals in the United Kingdom itself and about 130,000 of these terminals across Europe (Payments Cards, 2012).

The business potential of m-payment is enormous. According to IE Market Research Corporation (IEMR, 2012), the revenue for the global mobile payment is anticipated to increase from USD47.2 billion in 2011 to USD998.5 billion in 2016; meanwhile, Compound Annual Growth Rate (CAGR) is expected to increase to 83.7% from 2012 to 2016. The m-payment transaction in the US is anticipated to reach USD56.7 billion in 2015 from USD5.2 billion in 2009, a CAGR of 49.19% and constituted 10.6% of the global m-payment transaction (ResearchandMarkets, 2010). Global Information Inc. (2011) reported that the global m-payment users stood at 158.1 million in 2011 and is anticipated to increase to 1 billion at the end of 2016 while m-payment volumes stood at USD159.3 billion in 2011 and are estimated to reach USD1 trillion by the end of 2016.

Although there is availability of advanced technologies to support m-payment systems, their adoption and penetration rate is relatively low in comparison to other mode of cashless or contactless payments like credit cards and e-payment systems (Dahlberg et al., 2008). Besides, there have been hardly any major success stories of m-payment adoption elsewhere in the world except maybe in Japan and to certain level in South Korea (Bradford & Hayashi, 2007). Therefore, there is indeed a need to investigate the antecedents of m-payment adoption in the context of m-credit card in order to provide more insight into the determinants that affect the intention of consumers to adopt m-credit card. There has been paucity in the research of NFC-enabled mobile phones and limited researches (Chidembo, 2009; Madlmayr et al., 2008) have been conducted so far. Although there were many studies on technological innovations, very few were done pertaining to the use of innovative NFC technology in mobile payment. Hence, this study will serve to narrow the research gap by examining the determinants of m-credit card adoption using a trust-based Technology Acceptance Model (TAM). It will also investigate the moderator effects of age, gender, usage and the experience while investigating the causal relationships of these determinants. Therefore, the research questions for this study are:

RQ1: What are the determinants of mobile credit card adoptions?
RQ2: Do gender, age, experience and usage moderate the causal relationships between these determinants?

The structure of this paper is as follows. The next section will present the literature review of the past studies. Then, we proceed with the factors that influence mobile credit card adoption and followed by the hypothesis development of these factors. After that, the methodology and data analysis are elucidated before the discussion of the research findings. Finally, we present the limitations, implications and future directions of this study.

2. Literature review

2.1. Overview of NFC-enabled mobile payment

NFC is "a wireless communication technology that enables transfer of data over distances of up to 10 cm by combining technologies from RFID and contactless smart cards" (Madlmayr, 2008, p. 563). It was the brainchild of Sony and Philips which founded the NFC Forum. NFC uses the 13.56 MHz carrier frequency enabling devices to transfer data at 424 kbps (Chidembo, 2009). An NFC device may operate in three modes, i.e., read/write, peer-to-peer and card emulation mode. The read/write mode enables the NFC devices to passively read and exchange data store on NFC compliant transponders like tags while the card emulation mode enables the NFC devices to function as a smart card in which data can be read using an external reader. Last but not least, the peer-to-peer mode allows the sending and receiving of data between two NFC devices actively or simultaneously. NFC technology may be applied in a variety of industries including manufacturing, transportation, financial institutions, automobile, medical, advertising and etc. NFC-enabled mobile payment has been initiated in several countries as shown in Table 1.

In Malaysia, Visa launched its world's first commercial application of NFC-enabled mobile payment solution named Maxis FastTap in 2009. It was a partnership between Maxis, Visa, Nokia, Maybank and Touch n' Go. Maxis FastTap uses the Visa's payWave solution and allows NFC-enabled Nokia 6212 classic mobile phone to download the Maybank Visa payWave credit card over the air (Chidembo, 2009). This has enabled m-credit card to be used in 1800 merchant outlets throughout Malaysia (Near Field Communications World, 2012). Some of these outlets were shown in Table 2.

2.2. Factors influencing the adoption of NFC-enabled mobile payment

In order to investigate consumers' intention to use a new technology, many models have been developed and proposed. This include Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), Diffusion of Innovation (DOI), TAM model 2 (TAM2) and the Unified Theory of Acceptance and Use of Technology (UTAUT).

2.2.1. TRA

TRA (Fig. 1) was conceptualized in 1967 to investigate the relationship between attitudes, subjective norm and behavioral intention. Behavioral intention is influenced by one's attitude whether favorable or unfavorable in the performance of a behavior and also the social influence that can significantly affect one to think whether he or she should perform or not perform the behavior.

Table 1
NFC-enabled mobile payment initiatives. Source: Chidembo (2009).

Country	Project/initiative (partnership)	Time frame	Infrastructure	Result
Canada	CitiCards (Citi Canada and Bell Mobility)	August 2008 to November 2008	MasterCard's PayPass	Consumers are able to pay at Rabba Fine foods, Cineplex Odeon, and Petro-Canada
US	Pay-Buy-Mobile initiative (MasterCard Worldwide, 7-Eleven and Nokia)	2006 to 2007 (six months)	MasterCard's PayPass	Consumers may pay at 7-Eleven convenient stores at about 30,000 outlets in Japan, Taiwan, Thailand, South Korea, China, Hong Kong, Malaysia, Mexico, Singapore, Australia, Philippines, Norway, Sweden, Denmark and South Africa
UK	(O2, Barclaycard, Visa Europe, Nokia, Transport for London, AEG and Transys)	November 2007 to May 2008 (six months)	Visa payWave	Nine out of ten participants were satisfied with the NFC-enabled mobile payment solution and 78% thinking of adopting it once it has been commercialized
Switzerland	Visa Europe (Credit Suisse, PostFinance, Swisscard, Swisscom and Telekurs)	–	Visa payWave	Consumers are able to conduct proximity macro-mobile payments
Japan	MasterCard Worldwide (SoftBank Mobile, Orient, Samsung Electronic, Gemalto and Hitachi)	–	MasterCard's PayPass	Use of single chip NFC-enabled SIM card developed by Gemalto
Philippines	GSMA initiative – Pay-Buy-Mobile (Smart Communications, Giesecke & Devrient and MasterCard)	–	MasterCard's PayPass	SMS notification sent to the participant after every successful transaction
UAE	Jumeriah Beach Residence (Dubai First and du)	Six months	MasterCard's PayPass	250 Platinum MasterCard clients were selected for the trial. No mention was made on whether single or dual chip approach was used and type of mobile devices

Table 2
Maxis FastTap touch points. Source: www.maybank2u.com.my (2012).

Maybankard visa payWave merchants	Touch n' go	Retail	Others
Carrefour	Tolls nationwide	A&W	Caltex Petrol Stations
Parkson	Rapid KL LRT stations	Burger King	7 Eleven Convenience Stores
Watsons	Rapid KL Buses	Dunkin Donuts	Bank Negara Cafe
Baskin Robbins	KTM Kommuter	Baskin Robbins	Mercu UEM Cafe
Hush Puppies	Monorail	Steven's Tea Garden Café	
KLIA Express Rail Link (ERL)	Selected Parking Lots (32 in KL)	Kaya Kopitiam	
Nandos		Golden Oven	
Toy City		Station 1 Café	
The Body Shop		Daily Fresh	
Jusco @ AEON		Cathay Cineplex	
O'Briens			

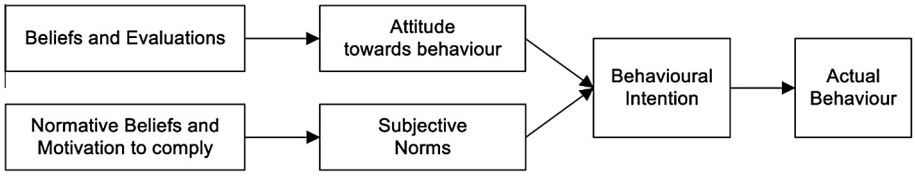

Fig. 1. TRA (Fishbein & Ajzen, 1975).

Attitude on the other hand depends on belief and evaluations while subjective norm is influenced by normative beliefs and the need to imitate. In this context, attitude is defined as the degree to which one has favorable or unfavorable evaluation of the behavior; whereas subjective norm is subject to one's belief whether others believe he or she should involve in such a behavior. Behavioral intention is described as the extent to which one is willing to try and exert while performing a behavior. TRA has been supported by some scholars (Bagozzi, Baumgatner, & Yi, 1989; Davis, 1989).

2.2.2. TPB

TPB (Fig. 2) is an improvement of TRA through the introduction of the perceived behavioral control (PBC) construct. PBC is one's perspective on the ease or in the difficulty when performing a behavior of interest. On the other hand, Taylor and Todd (1995) defined PBC as one's perspective of the constraints, both internally and externally, on a certain behavior. With the inclusion of PBC, TPB has been able to predict a variance of 44.05% in behavioral intention instead of 37.27% in the TRA model (Hagger, Chatzisarantis, & Biddle, 2002).

2.2.3. TAM

TAM (Fig. 3) is a popular model which "identifies the causal linkages between individual user's attitudes and perceptions towards technology and the actual adoption of technology" (King & Gribbins, 2002, p. 2). TAM is based on TRA to explain and predict user's adoption across a range of information systems. In TAM, there lies two main constructs, which are perceived usefulness (PU) and perceived ease of use (PEOU). Davis (1989) asserts that an individual will tend to use an information system (IS) when they believe that it will assist their job performances. He further defined PU as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320) and PEOU as "the degree to which a person

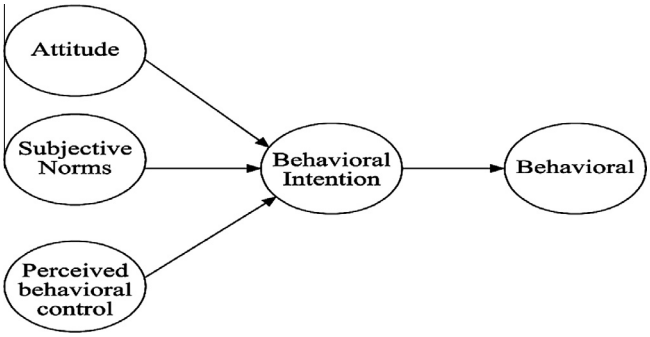

Fig. 2. TPB (Ajzen, 1985, 1991).

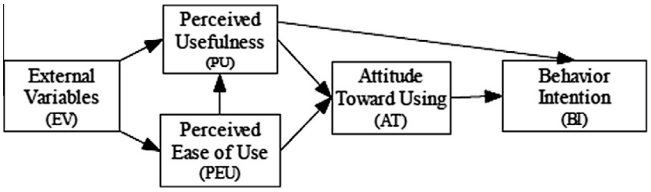

Fig. 3. TAM (Davis, 1989).

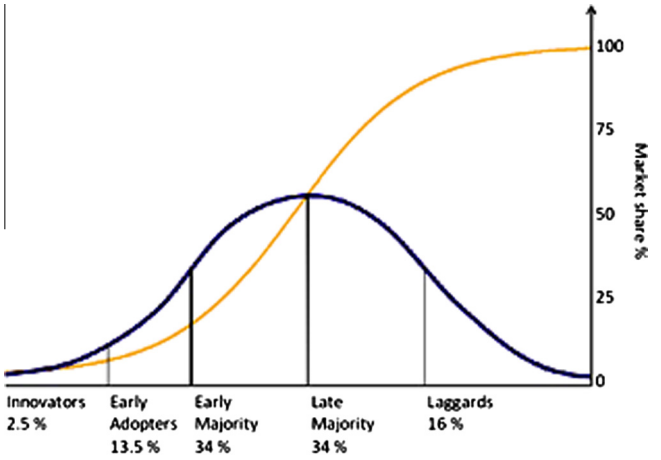

Fig. 4. DOI (Rogers, 2003).

believes that using a particular system would be free of effort" (Davis, 1989, p. 320). TAM is one of the many powerful and robust conceptual models in examining IS adoption (Davis, 1989; Mathieson, 1991; Taylor & Todd, 1995; Yang, 2005). It was found to have better explanation power than TRA and TPB (Mathieson, 1991). TAM has the ability to explain 53% of variance in behavioral intention (Taylor & Todd, 1995). TAM, as mentioned by Leong (2003), is one of the many used and cited models in the research of IS adoption. TAM has been validated empirically in various studies with different contexts, populations and IS such as prior experience (Agarwal & Prasad, 1999), mobile entertainment (Leong, Ooi, Chong, & Lin, 2011) and etc.

2.2.4. DOI

The DOI theory is based upon the key dimensions of diffusion, which are communication channels, innovation, social system and time. Rogers (2003) introduced the DOI model which encompasses five constructs, i.e., relative advantage, compatibility, complexity, observability and trialability. Relative advantage is similar to PU while complexity is similar to PEOU. Compatibility refers to the level in which innovation is believed to be in agreement with the present values, past experiences and the needs of prospective users. Trialability is described as the degree in which a new invention can be tested out on a limited time frame. Last but not least, observability is referred to as the degree in which the results of an innovation can be observed with others. An adopter may be categorized as innovator (venturesome), early adopter (respectable), early majority (deliberate), late majority (skeptical) or laggards (traditional) (Rogers, 2003) (Fig. 4). DOI is able to explain a variance in the range of 49% to 87% in adoption (Rogers, 2003).

2.2.5. TAM2

Sun and Zhang (2006) has suggested additional variables be added into the TAM model. This has led to the emergence of TAM2. TAM2 is an expansion of the previous TAM model, with an introduction of a few new factors such as social influence (subjective norm, image, and voluntarism) and cognitive instrumental processes (output quality, result demonstrability, experience and job relevance) (Fig. 5). It is developed based on four longitudinal studies accounting for 40% to 60% of the variance in PU and 34% to 52% in behavioral intention (Venkatesh & Davis, 2000).

2.2.6. UTAUT

Venkatesh, Morris, Davis, and Davis (2003) incorporated the theories of TRA, TAM, TPB, DOI, motivational model (Davis, Bagozzi, & Warshaw, 1992), social cognitive theory and PC utilization model into UTAUT model (Fig. 6). Even though this model is comprehensive, it has not been widely used by researchers as expected (Akour, 2009).

After examining the different types of IS adoption models, the TAM model was retained with the introduction of four new constructs, i.e., social influence (SI), personal innovativeness in information technology (PIIT), trust (TR) and perceived financial cost (PFC). SI and PIIT are psychological science constructs; TR is a trust-based construct while PFC is a behavioral control construct. Gender, age, experience and usage were introduced as the moderators to the model (Fig. 7).

3. Hypothesis formulation

3.1. Perceived usefulness (PU)

PU has been found to have significant influence on IU on various IS adoption such as mobile entertainment (Leong, Ooi et al., 2011), mobile credit card (Amin, 2007) and mobile payment (Dewan & Chen, 2005; Shin, 2010). The usefulness of mobile credit card can be seen from the abilities of the NFC-enabled device in running multiple proximity applications like payments and contactless reader leading to the innovative way of marketing and promoting applications whereby such applications can be uploaded into a secure area of the mobile device "over-the-air" thus providing opportunities for reducing the operational cost of the card issuing finance institutions and at the same time increasing the revenue for wireless network operators (Finextra, 2004). Based on the findings from the NFC-enabled Nokia 3220 mobile phone trials in Dallas, it was found that the mobile device which can automatically loads, personalizes and activates the PayPass payment application into the secure area (Finextra, 2006), is six seconds faster than payments by PayPass cards and this is especially useful for quick-pay businesses such as fast food restaurants, cinemas and petrol stations (Finextra, 2004). Furthermore, since there is no signature and entering of credit card number on small mobile phone keypad (Preece, 2006) as needed in the conventional credit card payment,

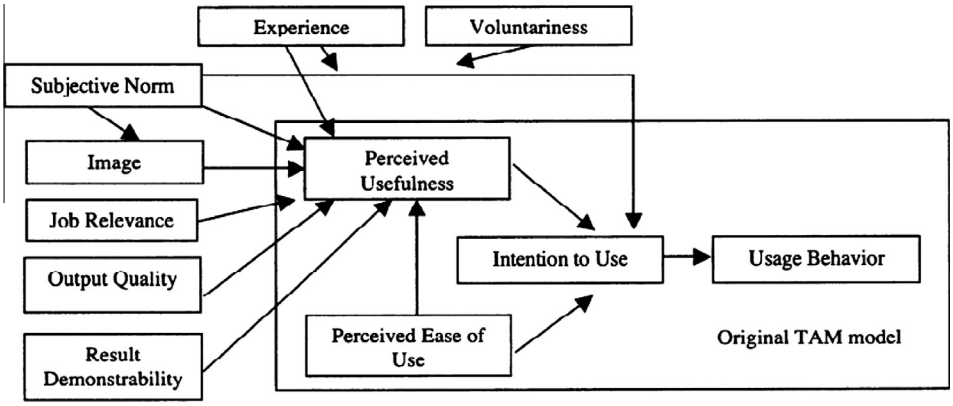

Fig. 5. TAM2 (Venkatesh & Davis, 2000).

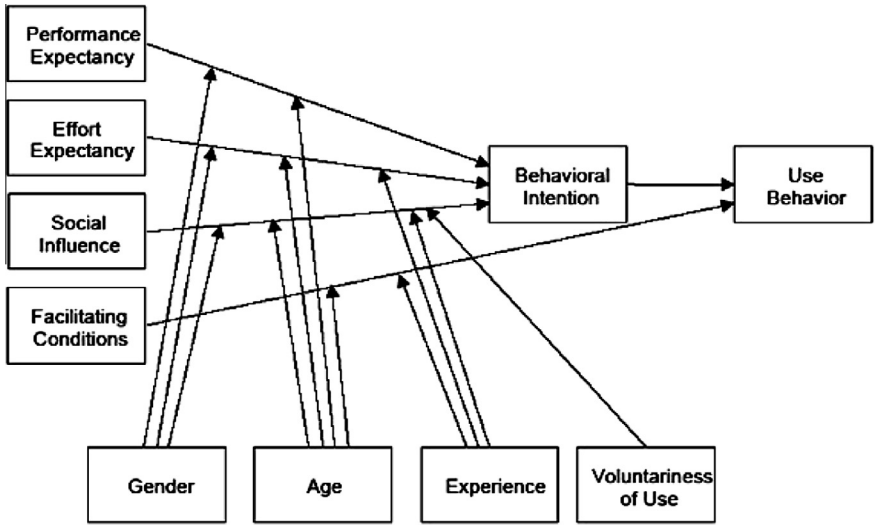

Fig. 6. UTAUT (Venkatesh et al., 2003).

the check-out time is much faster by just simply 'wave' the mobile device in front of the touch point. In view of the various usage and advantages of mobile credit card payment, the following hypothesis is formulated:

H_1. There is significant positive influence of PU on the intention to use mobile credit card.

3.2. Perceived ease of use (PEOU)

PEOU has shown significant impact upon IU of various IS adoption such as online banking (Guriting & Ndubisi, 2006) and mobile entertainment (Leong, Ooi, et al., 2011). When an IS is considered to be less complicated to use, the rate of such technology to be adopted will be higher (Teo, Lim, & Lai, 1999). Hence, the following hypothesis is posited:

H_2. There is significant positive influence of PEOU on the intention to adopt mobile credit card.

3.3. Social influence (SI)

SI refers to the level in which a person perceives that significant others (relatives, peers and friends) believe the individual should adopt the IS (Fishbein & Ajzen, 1975). SI is also known as subjective norm (Venkatesh & Davis, 2000). A study by Shen, Laffey, Lin, and Huang (2006) revealed that SI explained 39.9% of variance in PU and 11.4% in PEOU. Willis (2008) also found that SI is a significant antecedent of PU in online social networking behavior. On the other side of the coin, Teo (2010) concluded that SI can significantly affect PEOU. Hence, the following hypotheses are put forward:

H_3. There is significant positive influence of SI on PU.

H_4. There is significant positive influence of SI on PEOU.

3.4. Personal innovativeness in information technology (PIIT)

PIIT is defined as "the willingness of an individual to try out any new information technology" (Agarwal & Prasad, 1998, p. 206). PIIT is a moderator between perceptions and decision to adopt an information technology (Agarwal & Prasad, 1998). PIIT was found to significantly affect PU and PEOU (Parveen & Sulaiman, 2008; Yang, 2005). Hence, the following hypotheses are proposed:

H_5. There is significant positive influence of PIIT on PU.

H_6. There is significant positive influence of PIIT on PEOU.

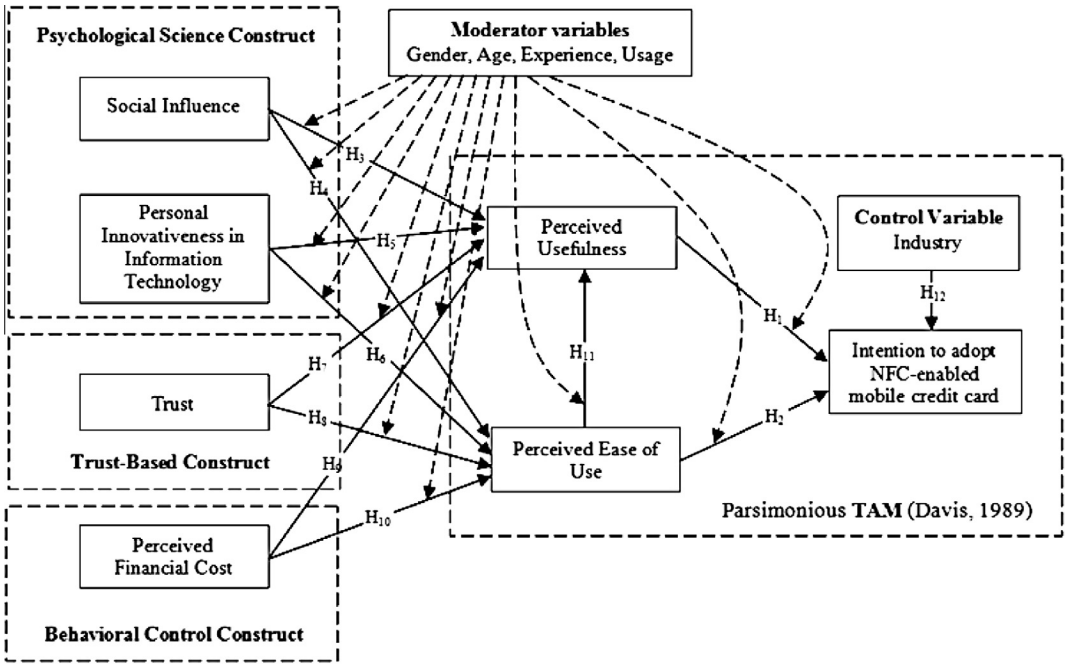

Fig. 7. Research model.

3.5. Trust (TR)

Various definitions have been given to TR. In e-commerce, Pavlou (2003) had defined TR as a belief that customers entrust upon online retailers after careful consideration on the characteristics of retailers. He also opined that TR is the most important belief that incorporates truthfulness, reliability, benevolence and dependability. From the context of this study, TR is described as the degree in which one believes that the usage of mobile credit card is trustworthy and reliable.

Pavlou (2003) has found that TR can significantly affect both PU and PEOU. This is due to the fact that a trustworthy IS will be considered by consumers as worry-free and secure. Besides, the trustworthy IS will also be more effortless as consumers do not have to bother about controlling and monitoring of situations based on the theory that the higher the degree of TR of a website, the less effort is required to examine the information of the website as to assess the benevolence of the merchant. Hence, the following hypotheses are postulated:

H_7. There is significant positive influence of TR on PU.

H_8. There is significant positive influence of TR on PEOU.

3.6. Perceived financial cost (PFC)

Perceived financial cost in the usage of IS will affect the adoption rate (Ong, Poong, & Ng, 2008). This has been proven in the adoption of SMS whereby the low cost of sending SMSes has stimulated its adoption rate (Antoine, 2004). In this study, PFC refers to the cost of buying a mobile phone, subscription fee, service fee, communication and transactional fee and cost of maintenance. He (2009) found that PFC can significantly and negatively affect PU and PEOU. Usefulness and ease of use are taken from the capability in reducing cost, time and effort (Liang, Chen, & Turban, 2009). Thus, we proceed with the following hypotheses:

H_9. There is significant negative influence of PFC on PU.

H_{10}. There is significant negative influence of PFC on PEOU.

3.7. Perceived ease of use (PEOU) and perceived usefulness (PU)

The association between PEOU and PU has been confirmed in various studies. PEOU does prove to have a significant effect upon PU in studies related to information technology (Agarwal & Prasad, 1998), GPS device (Chen & Chen, 2011), e-commerce (Pavlou, 2003) and mobile credit card (Amin, 2007). Therefore, it can be seen that most people will assume an easy to use product to be a useful product and hence the following hypothesis is posited:

H_{11}. There is significant positive influence of PEOU on PU.

3.8. Control variable: Industry

To further account for the differences among various industries, we have included the construct of industry as the control variable in this study. It is selected based on the potential it has towards the adoption of m-payment. Besides, several previous studies (Oliveira & Martins, 2010; Teo, Lin, & Lai, 2009) have engaged industry as a control variable. Thus, the following hypothesis is put forward:

H_{12}. There is significant positive influence of industry on intention to use mobile credit card.

3.9. Moderators of gender, age, experience and usage

A lot of scholars were keen to study the moderating effect of gender, age and experience on the association between both independent and dependent variables (Lee, 2009). In fact, age was repetitively found to moderate perceived ease of use (effort expectancy), perceived usefulness (performance expectancy), facilitating conditions and social influence in TAM-related researches (Lu, Yu, & Liu, 2006; Venkatesh et al., 2003). Gender and age were found to be the moderating factors when examining the linkage between perceived ease of use and perceived enjoyment in mobile broad-

band wireless access based games (Ha, Yoon, & Choi, 2007). Yu, Ha, Choi, and Rho (2005) found that experience was a significant moderating factor when investigating the linkage between perceived enjoyment, perceived usefulness, subjective norm and attitude. Hence, the following hypothesis was suggested:

H_{13}. Gender, age, experience and usage moderate all relationships among variables in the research model.

4. Methodology

4.1. Sampling procedure and data collection

Empirical data was gathered through the use of self-administered questionnaire. A cross-sectional survey was conducted with questionnaire administered to randomly selected users in the state of Perak, Malaysia. Over a period of two weeks, a total of 300 respondents from a convenient sample have participated in the main survey. Of this, 265 questionnaires were returned and three were found to be incomplete thus the response rate is 87.3%. University students were selected since students at this age bracket are more open in adopting new ICTs (Yang, 2005). Furthermore, "these students come from all over Malaysia and consist of different races, religions and backgrounds, hence the findings may be generalized to represent the overall Malaysian context" (Leong, Ooi, et al., 2011, p. 367).

4.2. Instrument development

The survey instrument consists of two parts. The first part is related to the demographic profiles of the respondents. The second part was developed based on the constructs of SI, PIIT, TR and PFC together with the PU, PEOU and IU from the TAM (Davis, 1989). A five-point Likert scale was used to measure all of these constructs, ranging from "strongly disagree" (1) to "strongly agree" (5). To ensure both validity and reliability of the constructs are met, the items in the questionnaire were adapted from past studies. 26 items in total were used to represent the six constructs, i.e., PU, PEOU, PFC, SI, PIIT and TR while five items were used to capture the construct of IU. Prior to the main survey, we have conducted a pre-test involving 20 respondents to validate the instrument. The respondents were asked about the clarity, wording and format of the instrument. After that, to further validate both the reliability and validity of the instrument, a pilot-test was conducted.

5. Statistical analysis

5.1. Respondents' demographic profile

The empirical data consists of 68.3% females. 56.5% of the respondents aged between 21-25 years old, 0.4% aged between 36-40 and 43.1% below 20. Degree holders (68.3%) dominated the survey, followed by postgraduates (6.1%), diploma holders (12.6%) and others with no college degree. 29.4% of the respondents come from education industry, 15.6% from banking, 10.7% from financial institutional and the rest from other industries. In terms of experience in using mobile credit card, majority (95.8%) of the respondents have less than 3 years experience, 3.1% have 3–6 years of experience and the rest have over 6 years of experience. Finally, 45.8% of the respondents use mobile credit cards 1–3 times a month, 9.5% use 4–10 times a month and 0.4% use 11–20 times a month. Table 3 depicts the full demographic profile of the respondents in this study.

Table 3
Demographic profile of respondents.

		Frequency	Percent
Gender	Female	179	68.3
	Male	83	31.7
Age	Below 20 years old	113	43.1
	21–25 years old	148	56.5
	26–30 years old	0	0
	31–35 years old	0	0
	36–40 years old	1	0.4
Highest educational level	No College Degree	34	13.0
	Diploma/Advanced Diploma	33	12.6
	Bachelor Degree/ Professional Qualification	179	68.3
	Postgraduates	16	6.1
Respondent's industry	Banking	41	15.6
	Financial Institutional	28	10.7
	IT Related	3	1.1
	Manufacturing	1	0.4
	Retail	1	0.4
	Telecommunication	1	0.4
	Tourism	1	0.4
	Education	77	29.4
	Other	109	41.6
Experience of credit card use	Less than 3 years	251	95.8
	3 to 6 years	8	3.1
	Over 6 years	3	1.1
Frequency of credit card use per month	1 to 3 times	120	45.8
	4 to 10 times	25	9.5
	11 to 20 times	1	0.4
	Other	116	44.3

5.2. Statistical analysis

Due to the fact that data for both independent and dependent variables were gathered from a self-reported questionnaire, the issue of common method bias (CMB) might arise. CMB refers to whether variance among two variables overlapped due to the relationship between the underlying constructs (Lee, 2009). Therefore, we conducted the Harmon's single factor analysis and found that the common variance is just 27.786% (<50%). We then continue with the common latent factor (CMB = 15.761%) whereby all indicators were regressed to a common factor and marker variable method (CMB = 14.669%) whereby a marker variable was assigned and concluded that there was evidence of CMB non-issue. A two-step method was employed where the measurement model was first established through confirmatory factor analysis (CFA) for the purpose of validating the convergent and discriminant validity of the constructs (Leong, Hew, Ooi, & Lin, 2012; Leong, Ooi, et al., 2011; Teo, Cheah, Leong, Hew, & Shum, 2012). This is followed by hypothesis testing using the maximum likelihood estimation (MLE). Furthermore, to examine the moderator effects, multi group analysis was conducted.

Before any statistical analysis is performed, it is a prerequisite to test the content validity of the instrument. Content validity is described as the extent to which a construct is representative and understandable (Bharati & Chaudhury, 2004). To ensure content validity, items were adapted from previous researchers. It is vital to examine the criterion validity of the construct in order to assess how good a predictor can predict the outcomes of a dependent variable. This is done by examining the correlation coefficients of all independent variables with the response variable. As shown from the strength and direction of the correlation coefficients in column 2 and 3 in Table 4, all predictors can predict quite well the expected outcomes. Besides that, the unidimensionality of each construct is examined using the Goodness-of-Fit Index (GFI) and Comparative Fit Index (CFI) and as shown in Table 5, all fit indices are above the threshold of 0.90 (Hair, Black, Babin, & Anderson, 2010).

Table 4
Construct SEM correlation coefficients, discriminant validity and criterion validity test.

	PU	PEOU	PFC	SI	PIIT	TR	IU	AVE	MSV	ASV
PU	0.720	0.540**	−0.097	0.185**	0.396**	0.344**	0.527**	0.519	0.292	0.148
PEOU	0.540**	0.710	−0.110	0.168**	0.390**	0.278**	0.479**	0.504	0.292	0.132
PFC	−0.097	−0.110	0.747	0.034	−0.095	−0.076	−0.169**	0.557	0.029	0.011
SI	0.185**	0.168**	0.034	0.794	0.252**	0.256**	0.305**	0.630	0.093	0.046
PIIT	0.396**	0.390**	−0.095	0.252**	0.712	0.337**	0.467**	0.512	0.218	0.119
TR	0.344**	0.278**	−0.076	0.256**	0.337**	0.795	0.455**	0.631	0.207	0.098
IU	0.527**	0.479**	−0.169**	0.305**	0.467**	0.455**	0.758	0.575	0.278	0.176
Fornell–Larcker ratio[a]	0.562	0.579	0.051	0.148	0.426	0.328	0.483			

Light shaded cells indicate criterion validity; PU = Perceived Usefulness; PEOU = Perceived Ease of Use; PFC = Perceived Financial Cost; TR = Trust; SI = Social Influence; PIIT = Personal Innovativeness in Information Technology; IU = Intention to Use; AVE = Average Variance Extracted; MSV = Maximum Shared Variance; ASV = Average Shared Variance.

** Correlation is significant at the 0.01 level (2-tailed); elements on the major diagonal shows the square root of the AVE.

[a] Fornell and Larcker (1981).

5.3. Construct reliability, convergent and discriminant validity

Reliability indicates that "a scale should consistently reflect the construct it is measuring" (Leong, Hew, Ooi, & Lin, 2011, p. 506). As recommended by Nunnally and Bernstein (1994), the Cronbach's alpha value should not be less than 0.70. Kline (2005) further stressed that the composite reliability (CR) which is calculated based on the actual loadings of the construct must exceed 0.70 while the average variance extracted (AVE) surpasses the 0.50 threshold. Construct validity measures the degree to which "a scale measures what it intends to measure" (Hew & Leong, 2011, p. 21). Convergent validity is defined as the ability of a construct to produce the same outcomes even though various approaches are utilized. According to Fornell and Larcker (1981), convergent validity is manifested if:-

- All factor loadings are larger than 0.50;
- All CR exceeded 0.70; and
- All AVE exceeded 0.50 level

Table 5 illustrated that all of these criteria have been met with PIIT having CR value very close to 0.70. Hence, it has been statistically verified and confirmed that the reliability and convergent validity of the dataset have been met.

5.4. Multivariate diagnostic tests

Multivariate assumptions are the prerequisite of an SEM analysis. Hair et al. (2010) asserts that among the assumptions to be fulfilled are the nonexistence of outliers and multi-collinearity problem, linearity and normality of distribution as well as adequate sample size. No outliers were detected since all Mahalanobis d^2 distances are in acceptable range. Multi-collinearity problem which arises from the high inter-correlations between the independent variables was evaluated by inspecting the Variance Inflation Factor (VIF) and its tolerance. Referring to Table 6, all VIF values should not exceed 10 and tolerance value must be greater than 0.10, as stated by Kline (2005). In addition, the maximum correlation coefficient value of 0.540 is between PEOU and PU, which is less than 0.90 indicating non-existence of multi-collinearity problem. Linearity of the distribution was examined using the matrix scatter plots and normality of the distribution is assessed in accordance to both skewness (0.631) and kurtosis (0.777), which has been proven to be less than three and ten respectively (Kline, 2005). Further assessment of normality was also verified by examining the normal Q-Q plot. Hair et al. (2010) opined that an adequate and satisfactory sample size for SEM should be between 100 and 200. Many researchers have used sample size within this range, e.g., 163 by Lederer, Maupin, Sena, and Zhuang (2000), 159 samples by Teo and Pian (2003), 121 by Wong, Ngan, Chan, and Chong (2012), 182 by Chong and Chan (2012) and 140 by Chong (2013b). Since the sample size in this study is 262, we conclude that it has exceeded the satisfactory range and deem adequate. Therefore, the multivariate assumptions were not violated in this study.

5.5. Confirmatory factor analysis (CFA)

To ensure that each item in the instrument is uniquely different from each others, discriminant validity test is conducted. Discriminant validity is met if all MSV and ASV are less than the AVE or the square root of AVE is larger than their correlation coefficients and these can be seen from Table 4. As an alternative, the Fornell-Larcker ratio was also computed, which is the ratio of the square of correlation coefficient to its AVE (Fornell & Larcker, 1981) and found that all ratios are less than one. Finally, we have calculated the confidence interval (± 2 standard errors) around the correlation estimate between two factors (Anderson & Gerbing, 1988, p. 416). As indicated in Table 7, all confidence intervals do not include 1 (Hernandez, Jemenez, & Martin, 2011). Therefore, all constructs have statistically passed the discriminant validity test.

5.5.1. Analysis of the measurement model

The chi-square statistics of the measurement model was found to be 139.126 with degree-of-freedom of 111, yielding a normed chi-square statistics of 1.253 which is less than 3.00 (Hair et al., 2010). Normed chi-square is used as a replacement of the chi-square test which is sensitive to sample size exceeding 200 (Jöreskog & Sörbom, 1994). When sample size increases, the chi-square statistics has the tendency to show significant differences for equivalent models (Lee, 2009). Therefore, other goodness-of-fit indices should also be examined and in this study, we have utilized the absolute fit indices, incremental fit indices as well as the parsimony-adjusted measures. As shown in Table 8, all of these indices have exceeded the recommended thresholds and indicated a good fit of the measurement model with the data collected.

5.5.2. Analysis of the structural model

The structural model's normed chi-square statistics is 0.816 which is less than 3.00 (Hair et al., 2010). Table 8 indicates that all fit indices had met the recommended thresholds. Therefore, we conclude that the structural model has been able to fit pretty well with the data collected.

5.5.3. Examination of the hypotheses in the structural model

Path analysis based on the p-value was was employed in order to verify the significance of a hypothesis. From the SEM analysis (Table 9), it was found that PU ($\beta = 0.260$, $p < 0.001$) and PEOU

Table 5
Construct reliability and convergent validity.

Constructs and their items	Indicator	Factor loading*	S.E.	Unidimensionality (GFI, CFI)	Cronbach's alpha (α)	Composite Reliability (CR[a])	Average Variance Extracted (AVE[b])
Perceived usefulness (PU)				(0.988, 0.990)	0.835	0.842	0.519
Using mobile credit card will enable me to accomplish my transaction more quickly	PU1	0.801	0.100				
Using mobile credit card increases my productivity/performance	PU2	0.689	0.105				
Using mobile credit card would enhance my effectiveness in my daily work	PU3	0.625	0.098				
Using mobile credit card makes the handling of payments easier	PU4	0.768	0.096				
Overall, I would find mobile credit card to be advantageous	PU5	0.704	n.a.				
Perceived ease of use (PEOU)				(0.987, 0.983)	0.748	0.752	0.504
Learning to use mobile credit card will be easy for me	PEOU1	0.650	0.101				
It would be easy for me to become skillful at using mobile credit card	PEOU3	0.732	0.102				
Since a mobile credit card uses my mobile phone, hence, a mobile phone credit card is easy to use	PEOU4	0.744	n.a.				
Perceived financial cost (PFC)				(1.000, 1.000)	0.762	0.784	0.557
The annual fees of mobile credit card services is expensive for me	PFC1	0.854	0.197				
The transaction fees is expensive	PFC2	0.819	0.185				
The cost of mobile phone is high for me	PFC3	0.521	n.a.				
Trust (TR)				(1.000, 1.000)	0.744	0.837	0.631
I would trust my bank to offer secure mobile credit card services	TR1	0.781	0.051				
I would trust my mobile phone manufacturer to provide a mobile phone which is appropriate for conducting mobile credit card services	TR2	0.818	0.048				
I believe that if an outsider gains access to my mobile credit card account, the bank will take complete responsibility for my money	TR3	0.784	n.a.				
Social influence (SI)				(0.998, 1.000)	0.762	0.773	0.630
Friend's suggestion and recommendation will affect my decision to use mobile credit card	SI1	0.826	n.a.				
Family/relatives have influence on my decision to use mobile credit card	SI2	0.760	0.088				
Personal innovativeness in information technology (PIIT)				(1.000, 1.000)	0.654	0.675	0.512
I like to experiment with new ways of doing things	PIIT2	0.635	0.171				
I like to take a chance	PIIT3	0.788	n.a.				
Intention to use (IU)				(0.988, 0.994)	0.876	0.871	0.575
I am likely to use mobile credit card in the near future	IU1	0.777	n.a.				
Given the opportunity, I will use mobile credit card	IU2	0.797	0.077				
I am willing to use mobile credit card in the near future	IU3	0.801	0.079				
I will think about using a mobile phone credit card	IU4	0.727	0.079				
I intend to use mobile payment services when the opportunity arises	IU5	0.682	0.077				

Note: Items PEOU2, SI3, SI4, SI5, SI6, PIIT1, PIIT4 and PIIT5 were discarded due to low loadings; GFI = goodness of Fit Index; CFI = comparative fit index. **Criteria**: Cronbach's $\alpha > 0.70$ (Nunnally & Bernstein, 1994), Composite Reliability (CR) > 0.70 and Average Variance Extracted (AVE) > 0.50 (Hair et al., 2010).

* Significant at $p < 0.001$; n.a. = not applicable.

[a] Composite reliability = (square of the summation of the factor loading)/{(square of the summation of the factor loadings) + (summation of error variances)}.

[b] Average variance extracted = (summation of the square of the factor loadings)/{(summation of the square of the factor loadings) + (summation of error variances)}.

Table 6
Multi-collinearity test: coefficients.[a]

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	Sig	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	0.518	0.299		1.734	0.084		
	PU	0.261	0.060	0.250	4.344	0.000	0.643	1.556
	PEOU	0.192	0.060	0.180	3.179	0.002	0.666	1.502
	PFC	−0.090	0.044	−0.095	−2.040	0.042	0.977	1.023
	PIIT	0.182	0.053	0.183	3.422	0.001	0.744	1.344
	SI	0.107	0.040	0.130	2.676	0.008	0.895	1.117
	TR	0.193	0.046	0.216	4.204	0.000	0.805	1.242

PU = perceived usefulness; PEOU = perceived ease of use; PFC = perceived financial cost; TR = trust; SI = social influence; PIIT = personal innovativeness in information technology; IU = intention to use.

[a] Dependent variable: IU.

($\beta = 0.193$, $p < 0.01$) have positive significant direct effect on IU. Hence, H_1 and H_2 were supported. PIIT ($\beta = 0.297$, $p < 0.001$) and TR ($\beta = 0.126$, $p < 0.05$) were found to have positive significant direct effect on PEOU and therefore H_6 and H_8 were supported. More-

Table 7
Confidence intervals (± 2 standard errors) for correlation estimate between factors.

	PU	PEOU	PFC	SI	PIIT	TR
PEOU	(0.448,0.659)					
PFC	(−0.197,0.022)	(−0.204,0.010)				
SI	(0.051,0.240)	(0.036,0.221)	(−0.077,0.136)			
PIIT	(0.269,0.482)	(0.258,0.466)	(−0.228,0.028)	(0.162,0.337)		
TR	(0.196,0.392)	(0.134,0.329)	(−0.187,0.044)	(0.150,0.406)	(0.200,0.406)	
IU	(0.406,0.604)	(0.347,0.548)	(−0.307,−0.051)	(0.230,0.512)	(0.362,0.580)	(0.388,0.632)

Note: PU = perceived usefulness; PEOU = perceived ease of use; PFC = perceived financial cost; TR = trust; SI = social influence; PIIT = personal innovativeness in information technology; IU = intention to use.

Table 8
Measurement and structural model fits.

Absolute fit indices				Incremental fit indices				Parsimony-adjusted measures			
Indicator	Threshold	CFA	Structural	Indicator	Threshold	CFA	Structural	Indicator	Threshold	CFA	Structural
GFI	⩾0.90[b]	0.948	0.994	CFI	⩾0.90[a]	0.982	1.000	RMSEA	⩽0.05[a]	0.031	0.000
AGFI	⩾0.90[b]	0.920	0.972	NFI	⩾0.90[c]	0.917	0.983				
SRMR	⩽0.05[d]	0.05	0.03	TLI	⩾0.90[c]	0.975	1.000				
RMR	⩽0.08[e]	0.08	0.07	IFI	⩾0.90[c]	0.982	1.000				

Note: GFI = goodness of fit index; AGFI = adjusted goodness of fit index; CFI = comparative fit index; NFI = normed fit index; IFI = incremental fit index; TLI = Tucker–Lewis index; RMR = root mean square residual; SRMR = standardized root mean square residual and RMSEA = root mean square error of approximation.
[a] Bagozzi and Yi (1988) and Hair et al. (2010).
[b] Byrne (2001) and Hair et al. (2010).
[c] Gefen, Straub, and Boudreau (2000).
[d] Leong, Ooi et al. (2011) and Jöreskog and Sörbom (1994).
[e] Browne and Cudeck (1993).

over, PIIT ($\beta = 0.158$, $p < 0.01$) and TR ($\beta = 0.137$, $p < 0.01$) also have significant influence on PU, hence H_5 and H_7 were accepted. Besides that, PEOU ($\beta = 0.433$, $p < 0.001$) was found to have positive significant direct effect on PU leading to the acceptance of hypothesis H_{11}. Finally, H_3 (SI → PU), H_4 (SI → PEOU), H_9 (PFC → PU) and H_{10} (PFC → PEOU) were all rejected.

5.5.4. Indirect effects

We have examined the significant level of the indirect effect by applying the bias-corrected percentile method's two tailed significance with bootstrapping (BC). The results in Tables 10 and 11 show that there are significant indirect effects of TR and PIIT on PU and IU. Similarly, PEOU also has significant indirect effect on IU.

Table 9
SEM analysis results.

	Path			Estimate	S.E.	C.R.	*p*-Value	Supported
H_1	PU	→	IU	0.260	0.059	4.380	0.000***	Yes
H_2	PEOU	→	IU	0.193	0.060	3.240	0.001**	Yes
H_3	SI	→	PU	0.025	0.041	0.601	0.548	No
H_4	SI	→	PEOU	0.039	0.045	0.855	0.393	No
H_5	PIIT	→	PU	0.158	0.054	2.942	0.003**	Yes
H_6	PIIT	→	PEOU	0.297	0.056	5.280	0.000***	Yes
H_7	TR	→	PU	0.137	0.046	2.955	0.003**	Yes
H_8	TR	→	PEOU	0.126	0.050	2.506	0.012*	Yes
H_9	PFC	→	PU	−0.021	0.045	−0.472	0.637	No
H_{10}	PFC	→	PEOU	−0.062	0.049	−1.252	0.211	No
H_{11}	PEOU	→	PU	0.433	0.056	7.696	0.000***	Yes
H_{12}	IND[a]	→	IU	0.089	0.098	0.909	0.364	No

Note: PU = perceived usefulness; PEOU = perceived ease of use; PFC = perceived financial cost; TR = trust; SI = social influence; PIIT = personal innovativeness in information technology; IND = industry; IU = intention to use.
*** p<0.001.
** p<0.01.
* p<0.05.
[a] IND is the control variable.

5.5.5. Mediating effect

To test the mediating effect of the mediator PU in the PEOU-PU-IU relationship, Baron and Kenny, (1986) technique was engaged as follows:

1. the IV → M, M → DV and IV → DV relationships must be significant;
2. for the IV + M → DV model:
   (a) M fully mediates the influence of IV on DV if M is significant and not IV
   (b) M partially mediates the influence of IV on DV if both M and IV are significant

As shown in Table 12, both IV and M are significant indicating that PU partially mediates the relationship between PEOU and IU.

5.5.6. Moderator effects of gender, age, experience and usage

The study on moderation effects in the grounded TAM is indeed paucity. In this study, the moderator effects were validated using the technique recommended by Jöreskog and Sörbom (1993). Significant moderator effect is verified if "the path was higher for the

Table 10
Indirect effects.

	TR	PIIT	PFC	SI	PEOU
PU	**.055**	**.128**	−.027	.017	.000
IU	**.074**	**.132**	−.024	.018	**.112**

Note: PU = perceived usefulness; PEOU = perceived ease of use; PFC = perceived financial cost; TR = trust; SI = social influence; PIIT = personal innovativeness in information technology; IU = intention to use.

Table 11
Indirect effects – two tailed significance (BC).

	TR	PIIT	PFC	SI	PEOU
PU	**.015***	**.008****	.206	.307	–
IU	**.013***	**.003****	.218	.404	**.004****

Note: PU = perceived usefulness; PEOU = perceived ease of use; PFC = perceived financial cost; TR = trust; SI = social influence; PIIT = personal innovativeness in information technology; IU = intention to use.
* $p < 0.05$.
** $p < 0.01$.

group which scored higher in some moderator and a drop in chi-square between the restricted and unrestricted model with one fewer degree of freedom was statistically significant" (Lee, 2009, p. 864). The results in Table 13 show that gender and usage do not have any moderating effect on all the paths in the structural model. Age and experience were found to have significant moderating effect on the TR → PEOU, PFC → PU and PEOU → PU, respectively. Therefore, H_{13} is partially supported. A summary of these moderating effects together with the significant paths is depicted in Fig. 8.

5.5.7. Artificial Neural Networks (ANN) analysis

ANN was engaged by using the significant determinants from the SEM analysis. ANN is defined as "a massively parallel distributed processor made up of simple processing units, which have a neural propensity for storing experimental knowledge and making it available for use" (Haykin, 2001, p. 2). ANN "resembles the brain in two aspects, i.e., knowledge is acquired by the network through a learning process while interneuron connection strengths known as synaptic weights are used to store the knowledge" (SPSS, 2011, p. 11). ANN normally consists of neurons or nodes that are distributed in three layers, i.e., input, hidden and output. Each of the input nodes is designated with a synaptic weight which is then passed to the hidden nodes in the hidden layers before they are transformed into an output value using a non-linear activation function such as sigmoid, hyperbolic tangent or arctangent. The synaptic weights of the neural connections will be adjusted via an iterative training or learning process and the outcome knowledge will be stored for future predictive usage. Although ANN has been applied in numerous fields, its application to information system studies remain scant (Shmueli & Koppius, 2010).

Since SEM can only examine linear model, it may sometimes oversimplifies the complexities in adoption decision. Hence an ANN approach which can identify linear and non-linear relationship was used to address this possibility. Besides, ANN does not require any distribution assumption (Chiang, Zhang, & Zhou, 2006) and may produce more accurate prediction and has out-performed other traditional regression techniques (Morris, Greer, Hughes, & Clark, 2004). However, due to its "black-box" operational method, it is not suitable for hypotheses testing of causal relationships. Thus, to overcome this shortcoming, the causal relationships were first examined using SEM and the significant factors extracted were taken as the input nodes of the ANN model to avoid over-fitting of the model. In this study, three models (Fig. 9) were analyzed using ANN multi-layer perceptron with feed-forward back-propagation algorithm provided in PASW 18. Sigmoid function is used as the activation function for both hidden and output layer of the ANN model. The number of hidden nodes was generated automatically. A 10-fold cross-validation approach with a ratio of 90:10 data for training and testing of prediction accuracy was engaged to generate the relative importance of the predictors (Chong, 2013a). Root Mean Square of Error (RMSE) from ten networks was used to examine the accuracy of the model (Chong, 2013b). Table 14 shows that the mean RMSE ranges from 0.1071 to 0.1128 for training and from 0.1020 to 0.1055 for testing. Hence, the models are very reliable to capture the relationships between predictors and outputs.

The significance of every independent variable is a measure of how well the predicted values of the ANN model changes with response to different values in the independent variable. In the sensitivity analysis, the normalized importance of the input variables was computed by dividing the importance of each input variable with the largest importance value in percentage form. Table 15 depicts the results of sensitivity analyses for the three models.

6. Discussion

From Table 9 and Fig. 8, PU is seen to be more important and has a stronger direct effect on IU compared to PEOU. These direct effects are in agreement with findings of Guriting and Ndubisi (2006), Leong, Ooi et al. (2011), Amin (2007), Dewan and Chen (2005) and Shin (2010). Thus, it can be concluded that PEOU and PU are crucial for successful NFC-enabled mobile credit card adoption among consumers. Although there are many studies on the impact of PEOU and PU on IT adoption, this study is among the first to examine their influence from the NFC-enabled mobile credit card perspective. Thus for successful adoption, the level of PEOU and PU should be high enough or else consumers will think that NFC-enabled credit card is difficult to use and has limited usages.

PIIT is more important and has greater direct effect on PEOU in comparison to TR. These findings are consistent with those of Yang (2005), Parveen and Sulaiman (2008). Hence, PIIT and TR are two main drivers of PEOU whereby the perception of PEOU is greatly dependable on the degree of PIIT and TR of the consumers. People with high PIIT tend to perceive that NFC-enabled credit card is as easy as 123 by just waving the mobile phone. Similarly, if their level of TR is high, one is more incline to think that the service is much easier to use in comparison to those that they do not trust.

PEOU has shown to have a stronger and direct effect upon PU compared to PIIT and TR. These results support the previous studies by Agarwal and Prasad (1998), Chen and Chen (2011), Pavlou

Table 12
Mediating effect.

Variable			Baron and Kenny test statistic (t)[a]	p-Value	Structural model's path coefficient					Degree of mediating effect
IV	M	DV			IV → M β_a (s_a)	M → DV β_b (s_b)	IV → DV	IV + M → DV (M controlled)		
								IV	M	
PEOU	PU	IU	4.821***	0.000	0.433*** (0.056)	0.342*** (0.055)	0.306***	0.193***	0.260***	Partial

Note: IV = independent variable; M = mediator; DV = dependent variable.
*** $p < 0.001$.
[a] Baron–Kenny test statistic is calculated using $t = \frac{\beta_a \beta_b}{\sqrt{\beta_a^2 s_b^2 + \beta_b^2 s_a^2 + s_a^2 s_b^2}}$ (Kenny, Kashy, & Bolger, 1998) where s = standard errors and β = coefficient of path; standard error is shown in bracket.

Table 13
Moderator effects: results of multiple group analysis.

	Gender $\chi^2(df = 32) = 31.094$			Male	Female	Chi-square difference[a]	*p*-Value[b]	Significant
H_1	PU	→	IU	0.397***	0.191**	2.924	0.0873	No
H_2	PEOU	→	IU	0.231*	0.182**	0.150	0.6985	No
H_3	SI	→	PU	0.008	0.027	0.052	0.8196	No
H_4	SI	→	PEOU	0.019	0.052	0.136	0.7123	No
H_5	PIIT	→	PU	0.062	0.202***	1.759	0.1847	No
H_6	PIIT	→	PEOU	0.317**	0.287***	0.069	0.7928	No
H_7	TR	→	PU	0.064	0.183***	1.747	0.1863	No
H_8	TR	→	PEOU	0.037	0.181**	2.291	0.1301	No
H_9	PFC	→	PU	−0.076	0.009	0.767	0.3811	No
H_{10}	PFC	→	PEOU	0.006	−0.099	1.041	0.3076	No
H_{11}	PEOU	→	PU	0.327**	0.477***	1.689	0.1937	No
	Age $\chi^2(df = 32) = 36.706$			Younger	Older			
H_1	PU	→	IU	0.288***	0.240***	0.199	0.6555	No
H_2	PEOU	→	IU	0.133	0.210**	0.507	0.4764	No
H_3	SI	→	PU	−0.020	0.050	0.801	0.3708	No
H_4	SI	→	PEOU	0.061	0.021	0.209	0.6476	No
H_5	PIIT	→	PU	0.192**	0.123	0.531	0.4662	No
H_6	PIIT	→	PEOU	0.303***	0.287***	0.025	0.8744	No
H_7	TR	→	PU	0.123	0.151*	0.103	0.7483	No
H_8	**TR**	→	**PEOU**	**0.243****	**0.056**	**3.945**	**0.0470***	**Yes**
H_9	PFC	→	PU	0.043	−0.043	0.876	0.3493	No
H_{10}	PFC	→	PEOU	−0.029	−0.079	0.238	0.6257	No
H_{11}	PEOU	→	PU	0.492***	0.399***	0.833	0.3614	No
	Experience $\chi^2(df = 32) = 48.365$			Low	High			
H_1	PU	→	IU	0.244***	0.430	0.185	0.6671	No
H_2	PEOU	→	IU	0.208***	0.462**	0.736	0.3909	No
H_3	SI	→	PU	0.030	−0.247	1.020	0.3125	No
H_4	SI	→	PEOU	0.034	0.363	0.447	0.5038	No
H_5	PIIT	→	PU	0.154**	0.198	0.024	0.8769	No
H_6	PIIT	→	PEOU	0.301***	0.461	0.103	0.7483	No
H_7	TR	→	PU	0.142**	−0.059	0.884	0.3471	No
H_8	TR	→	PEOU	0.104*	0.729*	3.146	0.0761	No
H_9	**PFC**	→	**PU**	**−0.038**	**0.493***	**4.932**	**0.0264***	**Yes**
H_{10}	PFC	→	PEOU	−0.037	−0.852*	3.628	0.0568	No
H_{11}	**PEOU**	→	**PU**	**0.479*****	**0.121**	**5.969**	**0.0146***	**Yes**
	Usage $\chi^2(df = 32) = 45.847$			Low	High			
H_1	PU	→	IU	0.227**	0.290***	0.348	0.5552	No
H_2	PEOU	→	IU	0.145*	0.228**	0.602	0.4378	No
H_3	SI	→	PU	0.069	−0.003	0.810	0.3681	No
H_4	SI	→	PEOU	0.133	−0.025	3.228	0.0724	No
H_5	PIIT	→	PU	0.076	0.224**	2.415	0.1202	No
H_6	PIIT	→	PEOU	0.274***	0.322***	0.201	0.6539	No
H_7	TR	→	PU	0.092	0.184**	1.083	0.2980	No
H_8	TR	→	PEOU	0.095	0.156*	0.411	0.5215	No
H_9	PFC	→	PU	−0.022	−0.025	0.001	0.9748	No
H_{10}	PFC	→	PEOU	−0.020	−0.126	1.098	0.2947	No
H_{11}	PEOU	→	PU	0.406***	0.460***	0.278	0.5980	No

Note: PU = perceived usefulness; PEOU = perceived ease of use; PFC = perceived financial cost; TR = trust; SI = social influence; PIIT = personal innovativeness in information technology; IU = intention to use.

[a] Chi-square difference = $\Delta\chi^2_{(\Delta df=1)}$.

[b] Two-tailed.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.000$.

(2003) and Amin (2007). Moreover, PEOU has the highest importance followed by PIIT and TR. Therefore, the level of PU can be affected by PEOU, PIIT and TR. When consumers perceive that it is easy to use NFC-enabled mobile credit card, they will also think that it is useful to them compared to a device which is difficult to use or operate. Likewise, when they have high level of PIIT and TR, they will consider the mobile credit card as a useful device since not much skill is required.

Surprisingly, the path analysis showed that there are no significant direct effects of SI and PFC on PU which is contrary to those of Willis (2008), Pavlou (2003) and He (2009). The non-significant effect of SI may be attributed to the fact that the usefulness of NFC-enabled mobile credit card is so widespread that influence from significant others (i.e., relatives, friends, peers or colleagues) does not seem to affect the perception of PU. Together with the higher level of education achievement among the consumers, they are able to judge by themselves the level of PU without the influence from others. The significant effect of TR indicates that trust plays an important role as an antecedent of PU and PEOU as consumer who trust NFC-enabled mobile credit card tend to perceive it as more useful and easier to use. The non-significance of PFC may be justified by the very low cost of owning an NFC-enabled mobile credit card that some bankers even provide free renewal and waive of annual service charge or government service tax. Hence, PFC does not seem to be a factor of consideration in assessing the PU level.

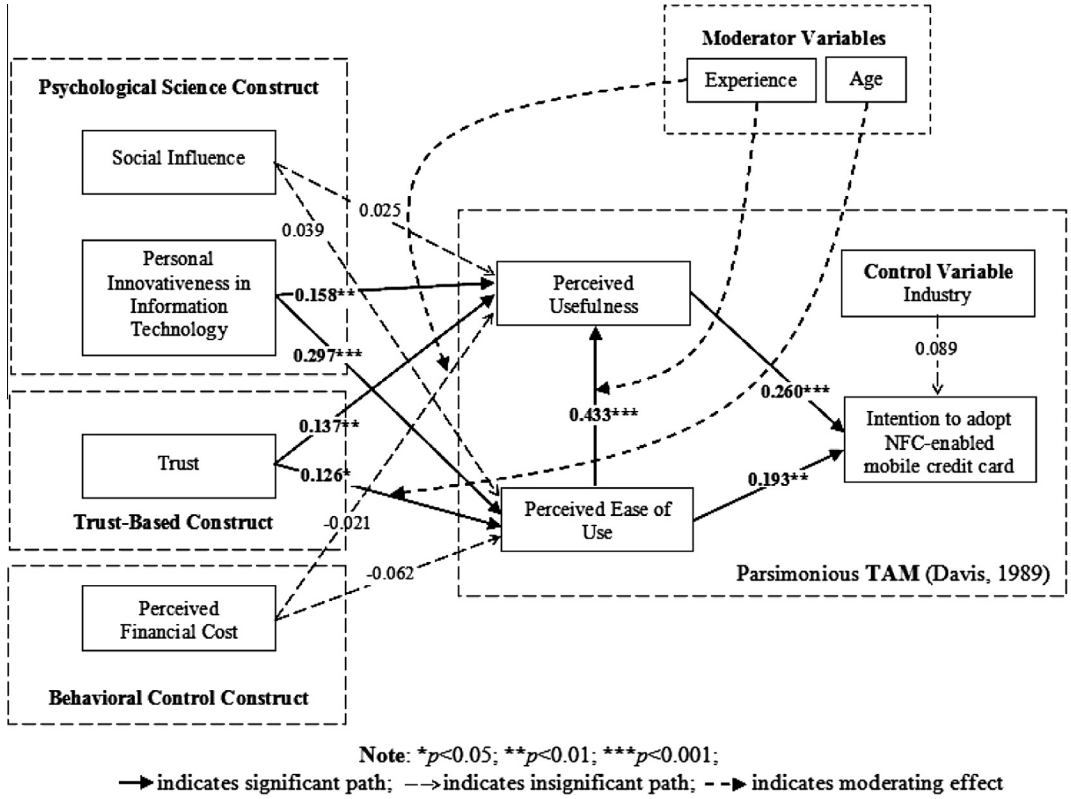

Fig. 8. Summary of SEM results.

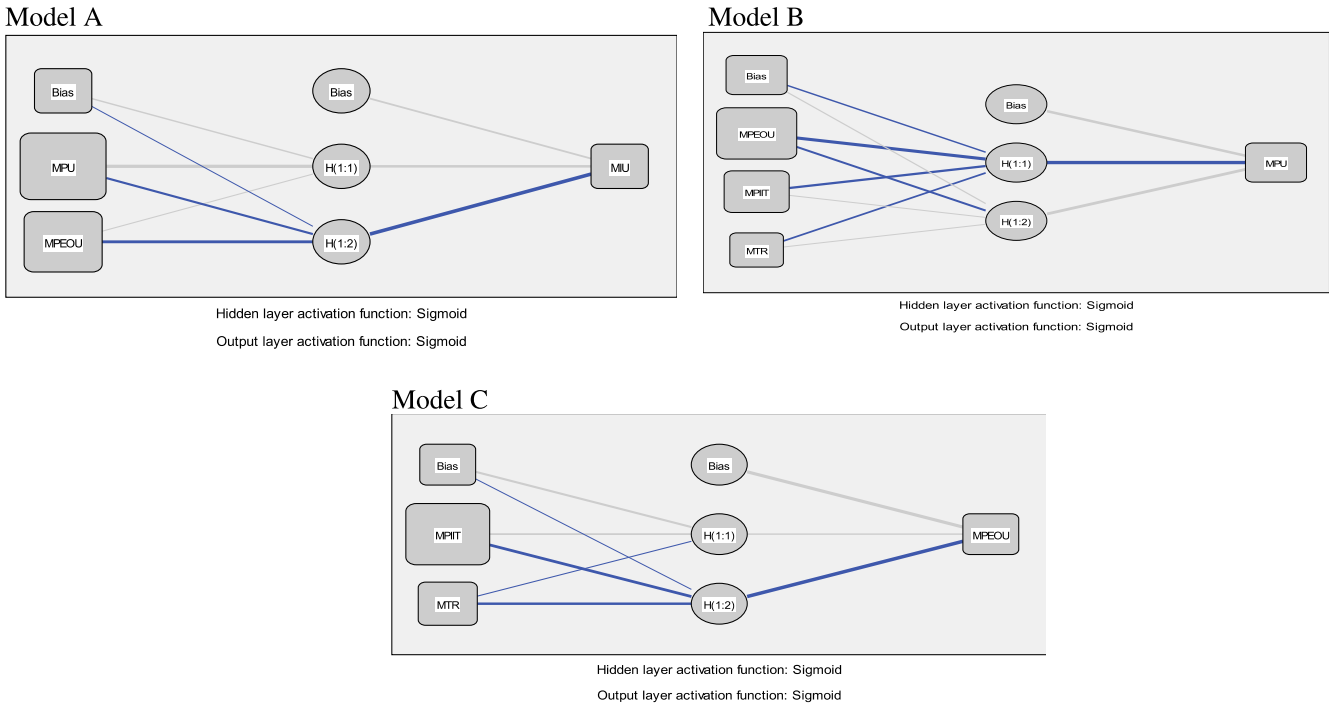

Fig. 9. Example of three ANN networks. Note: Hidden and Output layer activation function: Sigmoid; MPU, MPEOU, MPIIT, MTR, MIU are mean values for PU, PEOU, PIIT, TR and IU.

Equally surprising, there are also no significant direct effects of SI and PFC on PEOU which are contrary to findings by Shen et al. (2006), Teo (2010) and He (2009). Consumers are able to make their own judgment on the degree of PEOU without being influenced by the important others. Therefore, SI and PFC are non-factors in terms of measuring the level of PEOU. Since the cost of owning mobile credit card is relatively low, consumers do not make their decision on PEOU based on the PFC factor.

Table 14
RMSE values of artificial neural networks.

Network	Model A Input units: PU, PEOU Output unit: IU		Model B Input units: PIIT, TR, PEOU Output unit: PU		Model C Input units: PIIT, TR Output unit: PEOU	
	Training	Testing	Training	Testing	Training	Testing
1	0.1034	0.1439	0.1069	0.0812	0.1082	0.1037
2	0.1063	0.1100	0.1094	0.0844	0.1075	0.1095
3	0.1063	0.1034	0.1034	0.1020	0.1077	0.1074
4	0.1082	0.0854	0.1077	0.0787	0.1095	0.0886
5	0.1063	0.1025	0.1036	0.1165	0.1076	0.1138
6	0.1077	0.0938	0.1049	0.1254	0.1287	0.1560
7	0.1063	0.1044	0.1089	0.0967	0.1106	0.0087
8	0.1063	0.1010	0.1065	0.1128	0.1313	0.1326
9	0.1077	0.0900	0.1184	0.1410	0.1078	0.1049
10	0.1122	0.1131	0.1037	0.1164	0.1092	0.0950
Mean	0.1071	0.1048	0.1073	0.1055	0.1128	0.1020
Standard deviation	0.0022	0.0162	0.0045	0.0205	0.0091	0.0380

Note: PU = perceived usefulness; PEOU = perceived ease of use; TR = trust; PIIT = personal innovativeness in information technology; IU = intention to use.

Table 15
Sensitivity analysis: normalized importance.

Network	Model A importance (%)		Model B importance (%)			Model C importance (%)	
	PU	PEOU	PEOU	PIIT	TR	PIIT	TR
1	53.7	46.3	54.7	28.0	17.3	69.7	30.3
2	56.8	43.2	44.9	24.4	30.7	60.4	39.6
3	53.8	46.2	62.0	22.8	15.1	63.6	36.4
4	54.2	45.8	54.5	19.7	25.7	61.0	39.0
5	57.0	43.0	55.4	19.5	25.0	68.1	31.9
6	56.2	43.8	45.0	32.1	22.8	61.0	39.0
7	55.7	44.3	42.0	29.6	28.4	54.6	35.4
8	55.4	44.6	66.9	18.0	15.1	61.1	38.9
9	59.6	40.4	52.5	31.7	15.8	66.9	33.2
10	53.5	46.5	60.1	22.0	17.9	62.6	37.4
Average importance (%)	55.6	44.4	53.8	24.8	21.4	62.9	36.1
Normalized importance (%)	100.0	79.9	100.0	46.1	39.7	100.0	57.7

Note: PU = perceived usefulness; PEOU = perceived ease of use; TR = trust; PIIT = personal innovativeness in information technology; IU = intention to use.

There are significant indirect effects of TR and PIIT on IU and PU with PIIT as the dominant driver. Hence, besides the direct effects of PU and PEOU on IU, due attention should also be given to PIIT and TR in order to boost the level of adoption. The justification is that when the consumers' PIIT and TR levels are high, the chances adoption will be greater. Besides that, PU acts as a partial mediating factor on the relationship of PEOU → IU, proposing that PU poses a partial influence on the relationship between PEOU and IU. Thus, due considerations should be given to both PEOU and PU in order to increase the level of adoption.

In the current study, the moderating effects of gender, age, experience and usage were examined by engaging the multiple group analysis (MGA) proposed by Jöreskog and Sörbom (1993) together with median split technique. Interestingly, the findings showed that age has moderating effects on the relationship of TR → PEOU supporting the work of Venkatesh et al. (2003). Thus, TR plays a greater role in impacting PEOU when the ages of consumers are higher. Similarly, experience moderates the PFC → PU linkage which is in agreement with Yu et al. (2005) but as the linkage is insignificant, this effect may be ignored. Surprisingly, gender and usage were found to have no significant moderating effects on all the paths which indicate that the structural model and its findings are robust across gender and usage. These results are contradictions to findings by Ha et al. (2007). A reasonable justification may be the gender equality and equal exposures towards access of education provided by the government have successfully eradicated differences in gender. Finally, based on the insignificant effect of the control variable, we may conclude that there is no difference in terms of NFC-enabled mobile credit card adoption among users from various industries.

7. Implications

This study has resulted in several theoretical, methodological and managerial implications which are explicated in the following sections.

7.1. Theoretical implications

From the theoretical viewpoint, the parsimonious TAM has been successfully expanded in this study by including the psychological science construct (i.e., SI and PIIT), trust based construct (i.e., TR) and the behavioral control construct (i.e., PFC) as the antecedents of TAM. Besides that, it has also examined whether gender, age, experience and usage level have any moderating effects towards the causal relationships among the predictors. Currently, there is scarcity in studies on these moderating effects towards the parsimonious TAM. Furthermore, the study has also investigated the mediating effect of PU towards the PEOU → IU relationship. Industry was introduced as a control variable and was found to be invariant. The extended TAM model constructed in this study is believed to be able to contribute to the knowledge bank as it was tested and verified through numerous advanced statistical analysis techniques. The findings from this study will narrow down the knowledge gap pertaining to the determinants of NFC-enabled

mobile credit card adoption while providing more evidences to support the grounded TAM.

7.2. Methodological implications

From the methodological perspective, this study has engaged several advanced statistical techniques in tandem with the SEM which include the Fornell–Larcker's ratio (1981) and confidence intervals (within two standard errors) suggested by Anderson and Gerbing (1988) for discriminant validity test, bias-corrected percentile with two-tailed significance using bootstrapping to measure the significance of indirect effects, Baron–Kenny's technique (1986) in examining mediating effects, and multiple group analysis with median split technique for assessment of moderating effects. More importantly, the use of ANN in examining non-linear and non-compensatory relationships will provide more comprehensive findings since it is able to compliment the SEM linear model. The rigorous statistical analyses and multi-method approach may serve as a reference point for future studies regarding statistical analysis methodologies and techniques.

7.3. Managerial implications

The managerial implications of the present research are crucial and comprehensive. First of all, managers, administrators or policy makers, CEOs of mobile credit card companies, mobile phone manufacturers, bankers, merchants as well as government and private practitioners may take into their considerations the impact of PEOU and PU on IU. They must ensure that the product or service is of highest level of ease-to-use and usefulness for their consumers. Therefore, easy user interface, online help desk, free-toll hotline and email, downloadable user manual, automated functions, quick reference card and etc may be ways to uplift the level of PEOU. Besides that, they may also conduct customer survey to collect the data consistently from time to time regarding customers' needs and level of satisfaction so that they can provide more usages while fulfilling their demands. Another way to improve PU is to invite more merchants as partners so that more contactless terminals are provided.

Secondly, they may also give due attention to the effects of TR and PIIT on PEOU. This can be done by providing high quality product or services including after-sale services. Besides, longer guarantee period and warranty may be offered to consumers. In order to raise one's willingness to experience new information technology (i.e., PIIT), promotional activities may be carried out from time to time. These may include distribution of free trial mobile credit cards to selected individual, demonstrations and testimonies by current users regarding the minimal IT skills needed to use NFC-enabled mobile credit card.

Thirdly, the effect of TR and PIIT on PU can be used in the research and development (R&D) stage so that the end product is always of utmost trustable quality and easy to use with minimal IT skills requirement while providing ample and relevant usages to the consumers as mentioned in the above sections. A product which is simple to operate and need little skills will surely entice more users to accept its usage. Conversely, a hard to operate and heavy-skill product will lead to users to think that it is less useful to them. Furthermore, since there are no significant direct effects of SI and PFC on PU and PEOU, more time, resources and efforts should be given to other more imperative determinants as mentioned above.

Forth, the significant indirect effects of TR and PIIT on IU and PU will bring about the necessity to incorporate these determinants in all levels of the companies from R&D, marketing and sales to after-sales services. Since TR and PIIT also have direct impacts on PU, it is therefore vital to put more attentions and efforts so that companies are able to not only entice new users but also retain their trust.

Fifth, based on the mediating effect of PU on the PEOU-IU relationship, companies must ensure that their product is of highest usage to their users. Various new concepts, models and applications should be introduced from time to time according to the needs and wants of their users. Besides that, the moderating effects of age and experience imply the need to provide explicit considerations for different groups of age and experience. Thus a "one size suits all" strategy should be avoided for consumer segments of various age and experience. Hence, product can be "customer-tailored" according to the needs of these customer segments by providing different services and applications to the young and old, experienced and inexperienced groups. More attention, efforts and resources should be given to younger and inexperienced users as the impacts for them are lesser compared to the older and experienced users as indicated in Table 13. Last but not the least, based on the insignificant impact of the control variable (i.e., industry); all parties involved in NFC-enabled credit card adoption can have freedom when tackling the needs and wants of users from various industries. A common strategy or approach can be deployed as there is no significant difference across various industries.

8. Limitations and future directions

Although rigorous and decent statistical analyses have been performed, the findings of this study are limited in that the study was carried out in Malaysia and hence the result cannot be used to make statistical inference on other geographical regions. Besides that the research model was limited to the psychological science, trust-based, behavioral control and parsimonious TAM constructs. Hence, future studies should consider furthering their exploration on the impact of other adoption models such as TAM2, UTAUT2 (Venkatesh, Thong, & Xu, 2012), DOI, Customer Satisfaction Model (CSM), Expectation-Confirmation Theory (ECT), Technology-Organization-Environment (TOE) framework and etc. The effect of time can also be examined in future studies through a longitudinal research. A cross-country or cross-culture study may also be conducted to further expand the generalizability of the study. Future researches may also incorporate the actual usage construct instead of the intention to use (IU).

It is also interesting and useful to study the determinants of continuance behavioral intentions to use mobile credit card as industry players are very keen on retaining their customers besides enticing new consumers. Besides that, other potential factors such as government policy, convenience of use, quality of service, intrinsic and extrinsic motivation, and perceived financial risk as well as individual characteristics or demographic profiles of the consumers may also be examined in order to increase the predictive power of the model. Finally, it is also very useful if we can study the influence of different consumer segments based on their demographic profiles using the Radial Basis Function (RBF) in the ANN model in order to identify the predictors of the mobile credit card acceptance as industry players are very interested in identifying the consumer behavior across different consumer segments to assist them in conceptualizing their marketing strategies and approaches.

9. Conclusion

This study has successfully examined the determinants of NFC-enabled mobile credit card adoption by extending the TAM framework with constructs from psychological science, trust-based and behavioral control theories. The findings revealed that there is a significant and direct relationship between both PEOU and PU on IU while TR and PIIT have significant indirect effects on IU. Similarly,

TR and PIIT have significant direct effects on PEOU and PU whereas PU has mediating effect on the PEOU → IU relationship. Age and experience were found to have moderating effects on certain paths of the structural model. The findings are substantial and important as they provide the valuable information not only for mobile phone manufacturers but also bankers, merchants, policy makers and private and government practitioners in terms of the NFC-enabled mobile credit card adoption. The various advanced statistical techniques and SEM-ANN approach have further enhanced the validity and reliability of the findings while providing reference for future studies.

Through the use of a two-stage linear compensatory SEM model complemented with a non-linear non-compensatory ANN model, the findings from the study have provided solid contribution to the body of knowledge whereby critical determinants of the mobile credit card were successfully identified and verified using a mixture of linear and non-linear models. Moreover, the findings have also revealed the moderating effects of age and experience as well as the insignificance of the control variable (i.e., industry). These findings have offered strong basis in obtaining more understanding and insight for decision making processes either by researchers or practitioners from the mobile credit card perspective in elevating the acceptance rate of their consumers with regards to the NFC-enabled mobile credit card applications.

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