

Integrating cognitive antecedents into TAM to explain mobile banking behavioral intention: A SEM-neural network modeling

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Published online: 10 June 2017
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Abstract Higher penetration of smartphones and 3G and 4G mobile networks have led to the higher usage of smartphones for mobile banking activities. This paper identifies key antecedents influencing the mobile banking acceptance. The research extends the original Technology Acceptance Model, by incorporating two cognitive antecedents, namely, autonomous motivation and controlled motivation, in addition to trust components for understanding adoption. Data were collected from 225 mobile banking users and analyzed using an innovative two-stage research methodology. In the first stage, structural equation modeling was employed to test the research hypotheses and identify significant antecedents influencing mobile banking acceptance. In the second stage, the significant antecedents obtained from the first stage were input to a neural network model for ranking. The results showed that trust and autonomous motivation are the two main predictors influencing mobile banking acceptance. Theoretical and practical implications of findings are discussed.

Keywords Autonomous motivation · Controlled motivation · TAM · Mobile banking · Perceived trust

1 Introduction

With the advancement of Information and Communication Technology and the emergence of 3G and 4G services by telecom companies, mobile technology has become an

integral part of our day-to-day life. Mobile services have been introduced in many different sectors including government, banking, healthcare, and commerce (Kapoor et al. 2015; O'Connor and O'Reilly 2016). Many services are now being offered through mobile devices, which can be accessed in real time, such as balance inquiries, fund transfers, bill payments, etc. (Alalwan et al. 2017; Alalwan et al. 2016; Hanafizadeh et al. 2014; Laukkanen and Kiviniemi 2010; Luarn and Lin 2005). Mobile banking is one of the key latest technological innovations of mobile communication technology. Mobile Banking (or M-Banking) refers to a service provided by banks or other financial institutions that allow its customers to conduct a range of financial and non-financial transactions (as summarized in Table 1). These transactions can be realized remotely using a mobile device such as a mobile phone or tablet on dedicated mobile applications (apps), provided by the financial institutions (Shaikh and Karjaluo 2015).

The number of mobile users is increasing significantly every year around the globe and expected to reach 5.07 billion by 2019 (www.statista.com). Mobile users are considering M-Banking services as an additional value offered to them for performing various banking activities in real-time in the highly competitive world (Alalwan et al. 2017; Chong 2013; Barati and Mohammadi 2009). Moreover, it provides a commercial opportunity to the financial institutions as banking users consider mobility as an important value proposition associated with mobile banking systems (Suoranta and Mattila 2004). M-Banking services contribute towards the creation of time and place utilities by removing location and temporal constraints, thus, enabling users to access their bank accounts and conduct banking transactions anytime and anywhere (Zhou 2011).

In this paper, the adoption of mobile banking is investigated in one of the important emerging economies in the Gulf Cooperation Council, Oman. Oman is a developing and oil

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Table 1 Financial & non-financial services offered through M-banking

Financial Services	Non-Financial Services
Bill Payments	Balance Enquiry
Peer-to-peer payments	Mini-bank Statement
Fund Transfers	PIN Change
Remittance	Cheque book request
Shopping and donations	Due alerts for payments
Mobile balance recharge	Locate ATMs
Dish TV Recharge & Top-up	Enquire Deposit Rates
M-Commerce	Loan calculator

based economy among Gulf Cooperation Council (GCC) countries with 3.63 million population. Despite the lower oil price affecting the economy in all GCC countries, Omani banking sector has achieved robust growth during 2015–2016 (TOO 2016). The high levels of penetration of smartphones present significant growth opportunities for increasing M-Banking usage and motivating financial institutions and telecommunication service providers by offering new mobile applications to increase and satisfy their customer base (Alalwan et al. 2017; Shaikh 2013; Shaikh and Karjaluo 2015). The mobile subscription has 151% of residents whereas, active mobile broadband subscription penetration has reached 79.8% of residents in the second quarter of 2016 (Telecommunication Regulatory Authority Report 2016). All major banks namely Bank Muscat, Bank Sohar, National Bank of Oman and others offer mobile banking services with various customer benefits.

Despite various benefits offered by the banking sector and widespread adoption of mobile devices in the developing countries, the adoption rate of M-Banking across the world is still low (Alalwan et al. 2017; Alalwan et al. 2016; Akturan and Tezcan 2012; Malaquias and Hwang 2016). For instance, the share of mobile banking users among mobile devices owners reported in the year 2016 was 51% in the United States of America (www.statista.com) and the share is expected to be much lower in the developing countries. Gulf News (2015) reported that GCC banks lag in smartphone banking and overall quality of experience of the digital customer interaction. Therefore, it is important to identify and predict key antecedents influencing behavioral intention towards adopting M-Banking services. This research, therefore, attempts to bridge the gap in the existing literature by analyzing the perceptions that users have toward this technology in Oman and to present a strategic framework for policy makers and practitioners to utilize the intrinsic benefits offered by M-Banking.

This study departs from prior research in three ways: First, it intends to explore the attributes that warrant the adoption of mobile banking among users as well as to provide a practical analysis, so that banks could articulate customer behavioral

intentions towards mobile banking adoption and formulate necessary strategies. Second, this study proposes a new research model which consists of two very well-known antecedents of original TAM such as perceived usefulness and perceived ease of use, and two new cognitive antecedents such as autonomous motivation, and controlled motivation along with trust. The integration of cognitive antecedents in the mobile banking research domain is the originality of this research model. Finally, this study intends to employ an innovative research methodology in two stages. In the first stage, structural equation model (SEM) was employed to understand the significant influence of antecedents on the M-Banking services acceptance. The second stage employed neural network model to identify the importance of the antecedents. Therefore, this study develops a more comprehensive and predictive model that can overcome the basic limitations of the existing model and provide a predictive analysis on the user perceptions of M-Banking adoption.

2 Literature review:

2.1 TAM and its extensions

Technology acceptance model (TAM), task-technology fit (TTF), diffusion of innovation (DOI), theory of reasoned actions (TRA), and unified theory of acceptance and use of technology (UTAUT) have been employed to analyze consumer behavior and antecedents influencing their decision to accept new information systems (Liébana-Cabanillas et al. 2017). Technology Acceptance Model (TAM) (Davis 1989; Davis et al. 1989) derived from the Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975) offers a powerful explanation for user acceptance and usage behavior of information technology. TAM is one of the most influential models and widely used to study the determinants of IS/IT acceptance. There has been much discussion about the incompleteness of TAM (Chong et al. 2015). Given that the original TAM examines only the perceived ease of use and perceived usefulness, researchers and practitioners may find that studies based on the model are not sufficient to provide enough guidance (Chong 2013). Several researchers have suggested extending TAM with additional constructs to gain the better understanding of consumer behavior (Chong et al. 2012). Several studies examined M-Banking factors by studying the antecedents of customer satisfaction and behavioral intention to use M-Banking. For example, Gu et al. (2009) adapted the technology acceptance model (TAM) to study the determinants of the customer intention to use M-Banking. By employing innovation diffusion theory (IDT) and the decomposed theory of planned behavior (DTPB), Brown et al. (2003) surveyed 162 respondents and discovered that perceived advantages, the opportunity to try out cell phone banking, the number of

banking services required by respondents and perceived risk significantly influenced people to adopt mobile banking. Yu and Fang (2009) identified six dimensions to measure post-adoption customer perceptions of M-Banking services including security service, interactivity, relative advantage, ease of use, interface creativity, and customer service, which were confirmed by exploratory and confirmatory factor analysis. Luo et al. (2010) showed that both trust belief and risk significantly drive customer's intention to adopt M-Banking.

Laukkanen and Kiviniemi (2010) tested the factors affecting the adoption of M-Banking in their study. They intended to find barriers of adoption of M-Banking. These factors included use, value, risk, tradition and image. Zhou (2012) used elaboration likelihood model (ELM) as the theoretical base to examine the effect of central cues (information quality and service quality) and peripheral cues (system quality, reputation, and structural assurance) on M-Banking user behavior. Wessels and Drennan (2010) conducted a study to identify and test the key factors stimulating and hindering the adoption of M-Banking, as well as the effect of user's attitude on the intention to use. They found out that perceived usefulness, perceived risk, cost, and compatibility have a significant effect on the adoption of M-Banking. Sripalawat et al. (2011) investigated factors affecting M-Banking acceptance, both on adoption side and barrier side, to explore the effects of those factors, to guide banks and financial firms to attract more customers, and to compare the differences and similarities of M-Banking key success factors from different countries (Hanafizadeh et al. 2014). Akturan and Tezcan (2012) studied M-Banking adoption tendencies among young people. Combining TAM model and risks of M-Banking adoption, they concluded that perceived use, social risk, performance risk, and perceived advantages have a significant direct effect on the attitude of individuals (Hanafizadeh et al. 2014). Shaikh and Karjaluoto (2015) reported motivations, attitudes, behavioral intention, social systems, and associations that influenced potential M-Banking users. Malaquias and Hwang (2016) studied trust based factor in mobile banking. In the literature review of several studies, Zhang et al. (2012) explored the ten key antecedents influencing the acceptance of mobile commerce and reported that social influence and perceived enjoyment are the most important.

2.2 Self-determination theory of motivation

Ryan and Deci (2000) defined the self-determination theory as “humans have the basic propensities to be intrinsically motivated, to assimilate their social and physical worlds, to integrate external regulations into self-regulations, and, in so doing, integrate themselves into a larger social whole”. The self-determination theory proposes two types of motivations namely, intrinsic and extrinsic. Extrinsic motivation can be defined as a type of motivation developed on the basis of

external rewards or punishments and intrinsic motivation can be defined as a type of motivation driven by interest and enjoyment derived from participating in the activity (Nikou and Economides 2017). The central idea of self-determination theory revolves around the notion of autonomy (Zhou 2016). Autonomy is defined as “the perceived origin or source of one's own behavior. It concerns acting from concerns and integrated values” (Deci and Ryan 2002). The autonomous motivation can be defined as the human behavior motivated by internally induced incentives (Zhou 2016). In the literature, intrinsic motivation is also considered as autonomous motivation. The notion of autonomy is considered opposite of the notion of control. The controlled motivation can be defined as externally evoked incentives (Zhou 2016). In the literature, many researchers have established that self-determination theory determines individual behavior in various research domains of information systems such as education (De Naeghel et al. 2016), online learning (Hartnett 2015), MOOCs (Zhou 2016), and mobile-based assessment (Nikou and Economides 2017). In addition Lee et al. (2015) argued that self-determination theory and technology acceptance model are complementing one another.

2.3 Integration of technology acceptance model and self-determination theory

The Technology Acceptance Model (Davis 1989) and SDT model (Ryan and Deci 2000) approach user behaviors towards the perception of new technologies in different ways. The focus of each model is different and each by itself is not able to provide a complete explanation of the user's behavior. Both models have their individual strengths and weaknesses. These models have complemented various other models such as UTAUT (Venkatesh et al. 2003), the D&M IS success model (DeLone and McLean 2003), the Task-Technology Fit (TTF) Model (Goodhue and Thompson 1995), integration of D&M IS success model and TTF model (Tam and Oliveira 2016) and others. The TAM and SDT model can complement each other to provide a robust research model (Lee et al. 2015). The combination of TAM and SDT models can overcome the shortcomings of these individual approaches, and the integration can enable a better understanding of mobile banking adoption. For example, TAM has less focus on the cognitive aspect of user's behavior compared to SDT model whereas the latter is not focused on the functional aspects of the new technology. The convergent antecedents of TAM and SDT model provide a better understanding of mobile banking adoption in Omani context.

2.4 Neural network

Artificial neural networks (ANN) are sophisticated and robust tools that can provide the higher order of accuracy than

traditional statistical tools (Chong 2013, Sim et al. 2014). Haykin (2001) defined ANN as “Artificial neural network or neural network is a massively parallel distributed processor made up of simple processing units, which have a natural propensity for storing experimental knowledge and making it available for use”. There are three layers in a neural network model namely input layer, hidden layer, and the output layer. Multilayer neural network models are considered very complex and powerful models can solve a problem of higher order of complexity. There are various types of ANN model available for different applications. The different types of ANN models can be summarized into four groups namely feed-forward neural networks, recurrent networks, radial basis function networks, and multi-layer perceptron network (Sim et al. 2014). Furthermore, Sim et al. (2014) have discussed the advantages of multilayer perceptron network in detail. This study employed the multilayer perceptron neural network model.

3 Research model and development of hypotheses

Behavioral intention determines the behavior towards new technology (Zhang et al. 2012) and is the key notion of the well-known technology acceptance model (TAM). TAM is one of many theoretical models used to explain users’ acceptance of a new information technology. The key antecedents of TAM are perceived usefulness and perceived ease-of-use. We have extended TAM by incorporating three constructs namely autonomous motivation, controlled motivation, perceived trust in addition to the key constructs of TAM, perceived usefulness and perceived ease of use. This new hybrid model (see Fig. 1) is proposed to study users’ intention to adopt mobile banking in Oman, a developing country.

3.1 Perceived usefulness

Perceived usefulness (PU), is defined by Davis (1989) as “the prospective user’s subjective probability that using a specific application system will increase in his or her job performance”. PU, one of the key antecedents of TAM, is consistently influencing the behavioral intention of users towards new information systems. Information system researchers (Venkatesh and Davis 2000; Chang and Tung 2008; Chong et al. 2015; Liébana-Cabanillas et al. 2017) have recommended that perceived usefulness have a positive relationship with behavioral intention to use new systems. In comparison to the perceived ease of use, the other integral constructs of TAM, perceived usefulness generally have a stronger impact on the acceptance of new technology (Davis 1989; Adams et al. 1992). Perceived usefulness is the key and most commonly used antecedents in the acceptance of any new

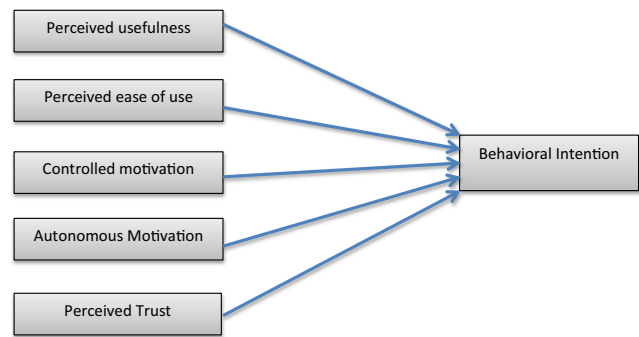


Fig. 1 Research Model

information systems including mobile banking. We propose the following hypothesis:

H1. There is a positive and statistically significant relationship between perceived usefulness and behavioral intention towards M-Banking acceptance.

3.1.1 Perceived ease of use

Perceived ease of use is defined as “the degree to which the prospective users expect the target system to be free of effort” (Davis 1989). Information systems researchers (Davis 1989; Adams et al. 1992; Mallat et al. 2009; Kim et al. 2007; Chong et al. 2015; Liébana-Cabanillas et al. 2014) have found that perceived ease of use have a positive and significant relationship with behavioral intention towards new information systems. Dai and Palvi (2009), in a cross-cultural study in the USA and China, found that perceived ease of use was the significant predictor of intention towards mobile commerce among Chinese consumers whereas, not significant predictor among USA consumers. Liébana-Cabanillas et al. (2014) found that perceived ease of use is the key predictor of behavioral intention towards mobile payments. Furthermore, Liébana-Cabanillas et al. (2017) found that there is no significant relationship between perceived ease of use and behavioral intention towards mobile commerce acceptance. As we reviewed the past studies, we found contradictions in the relationships between perceived ease of use and behavioral intention towards new technology. Thus, we propose the following hypothesis.

H2. There is a positive and statistically significant relationship between perceived ease of use and behavioral intention towards M-Banking acceptance.

3.1.2 Autonomous motivation

Creating a need for the supportive environment will help to achieve autonomous motivation (Vansteenkiste et al. 2007).

Giving the customers the right to choose among services can motivate them by making them feel that it is their choice and they can decide what service they should use. Once the new mobile banking (M-Banking) service is introduced to the customers, they will have a tendency to become the early adopter of the new service since they want to prove themselves that they are the initiators of their own actions. Therefore communicating, publishing and promoting about mobile banking will help to increase its acceptance through autonomous motivation. When something new comes up, people have an urge to know or use what it is. This enthusiasm or curiosity is one factor for autonomous motivation. Identify and focus on such group of curious/ enthusiastic customers and let ideas and information on mobile banking reach them. It is highly probable that those focused groups get motivated to adopt new technology themselves. Banks should be effective enough to make customers know why they need mobile banking and why should they use it. The benefits and advantages of M-Banking should be conveyed well to the customers through campaigns, exhibitions, presentations, customer meetings, and email promotions. Previous literature shows that recreational benefits directly influence the customers' attitude (Bellenger and Korgaonkar 1980; Sinha 2003). And if they feel that it can personally benefit them, they will decide to choose it for their personal achievement. Experience is another factor, which contributes towards autonomous motivation, and providing a trial run for those who are interested can do this. Making them feel good about the experience will make them use the M-Banking service more. Hagger et al. (2002) and Zhou (2016) argued that autonomous motivation plays a significant role in the user's behavioral intention. These arguments motivate to propose the following hypothesis.

H3. There is a positive and statistically significant relationship between autonomous motivation and behavioral intention towards M-Banking acceptance.

3.1.3 Controlled motivation

Controlled motivation relies on two approaches, creating purchase pressure and creating fear of not using the technology (Michou et al. 2014; Ryan and Deci 2000). Further, activities of the importance of promoting M-Banking include the use of marketing campaigns, commercial advertisements, and slogans on the benefits of mobile banking. These marketing tools seek to propagate that customers cannot do without mobile banking and may even associate a feeling of "shame" or "being unfashionable" with customers who do not use M-Banking. Moreover, banks may also mandate the use of M-Banking for some of the essential banking services for increasing the usage of M-Banking acceptance. Since customers are forced to use the compulsory services in the absence of

other options, they have to adopt M-Banking services. Hagger et al. (2002) and Zhou (2016) argued that controlled motivation, which is considered as opposite of autonomous motivation will have a significant impact on the behavioral intention of users. Therefore, the following hypothesis is proposed.

H4. There is a negative and statistically significant relationship between controlled motivation and behavioral intention towards M-Banking acceptance.

3.1.4 Perceived trust

Trust in the context of M-Banking can be defined as the perception of users towards the usage, as it is safe and has no privacy issues. M-Banking is relatively new information system and therefore users have limited experience of using it. Personal information is saved on mobile devices and hence security concerns are high (Chong 2013). In a recent study done by Yadav et al. 2016 and Liébana-Cabanillas et al. (2017), it was found that trust plays an important role in the acceptance of mobile commerce. Lin (2011) and Luarn and Lin (2005) observed that the significance of security and privacy was higher than perceived ease of use and perceived usefulness, the key antecedents of TAM. The impact of trust is relatively high on the acceptance of M-Banking. Therefore, we propose the following hypothesis.

H5. There is a positive and statistically significant relationship between perceived trust and behavioral intention towards M-Banking acceptance.

4 Research methodology

The methodology adopted in this research is similar to the previous studies (Shmueli and Koppius 2011; Chong 2013; Liébana-Cabanillas et al. 2017) to validate the research model and test the proposed research hypotheses. There are two stages in the data analysis of this study. In the first stage, structural equation model (SEM) was employed to understand the significant influence of predictors on the M-Banking acceptance. The second stage employed neural network model to identify the importance of the predictors.

4.1 Variable measurement

The proposed research model in this study includes five predictors and one outcome variable. There were twenty-one statements used to measure predictor variables whereas three statements were used to measure outcome variable. A Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree)

was used to measure statements. Descriptive analytics of outcome variable and predictors is summarized in appendix Table 6 whereas item details can be seen in appendix Table 7.

4.2 Data collection

A closed-ended survey was developed to understand and predict the impact of motivational antecedents, addition to key antecedents of TAM and perceived trust, on the intention to adopt mobile banking in a developing country. The survey was pre-tested with three university professors whose main research area is information systems and 15 frequent mobile banking users. The survey was revised on the basis of the results of the pre-test. The final survey was developed with the help of Google Docs, freely available tool for online surveys. The survey questionnaire link was shared among all faculty and staff through email in the public university of Oman.

5 Results

5.1 Respondents' profile and characteristics

Two hundred and twenty-five complete surveys were received in total. There were 46.2% female and 53.8% male participants in the survey. The age distribution of participants was as follows: 69.3% participants were below 35 years age and remaining participants belonged to more than 35 years age group. The majority of respondents were graduates (52.9%), followed by master's degree (36.4%) and diploma (10.7%) respectively. All respondents in this survey were M-Banking users and their years of M-Banking experiences was as follows: 24.5% respondents were having less than one year, 57.8% between one and three years whereas 17.8% respondents had more than three years of experience.

5.2 Results of measurement model

The research model was assessed using two stages. In the first stage, a measurement model was assessed whereas in the second stage research hypotheses were tested using structural model. The confirmatory factor analysis was employed to assess the composite reliability, convergent validity and discriminant validity of all decision constructs (Chong 2013). The Cronbach alpha was used to assess the reliability of all constructs. See the results summarized in Table 2 for reliability and validity of constructs. The composite reliability of all constructs was higher than 0.70, ensures the reliability of all constructs as per the recommendations of Hair et al. (2010). Since the values of composite reliability were greater than average variance extracted, the convergent validity of constructs was confirmed. Furthermore, the maximum shared values (MSV) of constructs were lower than average variance extracted

(AVE), ensures the discriminant validity. Reliability for the constructs can be computed using two measures, namely maximal reliability or MaxR(H) and Cronbach's alpha. In this study, reliability was measured using maximal reliability, which is similar to Cronbach's alpha (i.e., varies from 0 to 1) but more suitable for latent variables (Drewes 2000). However, both maximal reliability and Cronbach's alpha are reported in this study. Maximal reliability is "the squared correlation of the underlying latent factor with a linear composite of its indicators (Gagne and Hancock 2006). The minimum recommended value of maximum reliability is 0.70 for supporting the acceptable reliability of constructs. MaxR(H) represents maximal reliability of constructs which is considered the more robust measure in comparison to composite reliability. In this study, we have shown MaxR(H) in addition to the composite reliability of all constructs. The MaxR(H) for all constructs is higher than the threshold level of 0.70 (see Table 2)

The fitness of measurement model was assessed by a set of fit indices such as (Chi-Square/df) = 1.323, GFI = 0.923, AGFI = 0.893, TLI = 0.986, CFI = 0.989 and root mean squared error of approximation (RMSEA) = 0.038. Therefore, the measurement model is reasonably good fit.

5.3 Testing of hypotheses

The structural equation modeling (SEM) was employed to test the research hypotheses proposed in this study. All 5-research hypotheses were supported (see Table 3). The estimates and beta values of the constructs represent the unstandardized and standardized regression coefficients. The fundamental key antecedents of TAM, perceived usefulness (Beta = 0.175, p -value < 0.01) and perceived ease of use (Beta = .174, p -value = 0.01), have a positive and statistically significant relationship with the behavioral intention towards M-Banking acceptance, supporting hypothesis H1 and H2. These results imply that users are interested in the M-Banking services due to its usefulness as well as its ease of use. Furthermore, two key motivational constructs namely autonomous motivation (Beta = 0.216, p -value < 0.001) and controlled motivation (Beta = -0.111, p -value < 0.01) have positive and negative statistically significant relationship with the M-Banking acceptance respectively, supporting hypotheses H3 and H4. The results show that motivation is essential to use M-Banking services. Finally, trust (Beta = 0.382, p -value < 0.001) has a positive and statistically significant relationship with M-Banking services, supporting hypothesis H5.

M-banking services are still in its initial stage in many developing countries like Oman. The perceived trust plays a key role in the acceptance of M-Banking services from the user's perspective. In addition, it was observed that the all five predictors explain 65.4% of the variance in the behavioral intention towards the acceptance of M-Banking services in a developing country.

Table 2 Convergent and discriminant validity

	CR	AVE	MSV	MaxR(H)	CM	Trust	PU	PEOU	AM	BI
CM	0.931	0.819	0.167	0.943	0.905					
Trust	0.948	0.822	0.534	0.977	-0.409	0.907				
PU	0.858	0.668	0.317	0.980	-0.259	0.509	0.817			
PEOU	0.908	0.768	0.368	0.984	-0.275	0.577	0.461	0.876		
AM	0.889	0.728	0.348	0.986	-0.176	0.533	0.394	0.475	0.853	
BI	0.969	0.912	0.534	0.991	-0.398	0.731	0.563	0.607	0.590	0.955

5.4 Neural network results

This study developed neural network model in a commonly used statistical software SPSS 21. The statistically significant predictors were given as input to the neural network model. The number of input layers in the neural network model was five as covariates represented by significant predictors namely perceived usefulness, perceived ease of use, autonomous motivation, controlled motivation, and trust (see Fig. 2). The output layer of the network model was represented by the dependent variable namely behavioral intention towards M-Banking acceptance.

The multilayer perceptron training algorithm was employed to train the neural network model. Over-fitting is a major concern in the predictive modeling approach? In order to overcome the over-fitting of the model, cross-validation is considered a suitable approach (Chong 2013). The determination of exactly hidden nodes is considered one of the most difficult challenges in the literature. Wang and Elhag (2007) recommended a range of one to 10 hidden nodes in the neural network model. The 80 % of data points were used to train the neural network model and 20 % data points were used to test the model. The main objective of testing the model is to assess the accuracy of the model (Chong 2013; Sharma et al. 2016; Chong et al. 2015; Liébana-Cabanillas et al. 2017). In the neural network applications, it is recommended to use accuracy using the root mean squared error (RMSE). The RMSE for both training and testing of the neural network model is summarized in Table 4 along with the mean and standard deviations. The average RMSE values (for training data points was 0.117 and for testing data points was 0.139) were relatively small with very small standard deviations justifying the higher order of accuracy in the results predicted by the neural

network model (Yadav et al. 2016; Liébana-Cabanillas et al. 2017). The standard deviation for training and testing all hidden nodes was 0.012 and 0.011, supports the relatively lesser error in the neural network model.

The sensitivity analysis of the performance computed using the average importance of predictors in predicting outcome variable (Chong 2013). The normalized importance of predictors can be computed by dividing the importance of predictors by the highest value of the predictor (Liébana-Cabanillas et al. 2017). The importance of the predictors is summarized in Table 5. The results obtained from the neural network model shows that trust is the key predictor of the M-Banking acceptance followed by perceived usefulness, autonomous motivation, perceived ease of use, and controlled motivation.

6 Discussion

The aforementioned analytical results show that the research model examined in this study is acceptable. In this study, the original technology acceptance model (TAM) was extended by incorporating trust and two cognitive constructs namely autonomous motivation and controlled motivation. The value of the coefficient of determination (R^2) accounted behavioral intention was 65.4%, which is considered on the higher side of the acceptance level. Furthermore, the value of R^2 in this study is relatively higher than the other mobile banking studies. For example, Akturan and Tezcan (2012) conducted a study on mobile banking acceptance and found that the value of R^2 was 52.9%.

The statistical results in the preceding section revealed that trust is the most important construct with the beta value of 0.382 explaining the behavioral intention of users towards

Table 3 Structural model results

Paths	Beta values	Estimates	S.E.	C.R.	p-value
BI <--- Perceived Trust	0.382***	0.431	0.074	5.823	***
BI <--- Perceived Usefulness	0.175**	0.256	0.084	3.040	0.002
BI <--- Perceived Ease of Use	0.174**	0.187	0.063	2.958	0.003
BI <--- Autonomous Motivation	0.216***	0.323	0.085	3.802	***
BI <--- Controlled Motivation	-0.111**	-0.110	0.048	-2.294	0.022

*: $p < 0.05$; ***: $p < 0.001$; **: $p < 0.01$; BI: Behavioral Intention

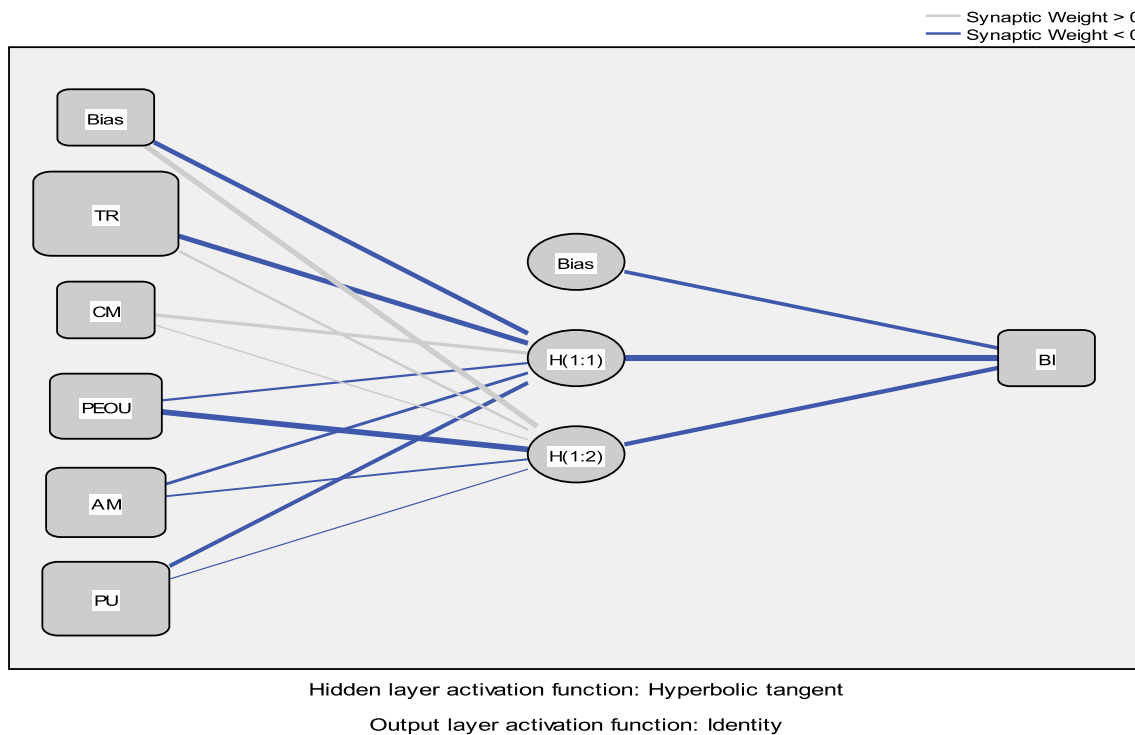


Fig. 2 Neural network model

mobile banking in a developing country like Oman. It shows that the higher level of trust influences the perception of users towards a new technology. This may be possible due to sensitive nature of financial transactions in mobile banking (Alalwan et al. 2017; Riffai et al. 2012). Hanafizadeh et al. (2014) recommended the use of experience marketing in this context where users are encouraged to use and experience services and decide whether they are good or bad. Trust has been tested and validated in several studies pertaining to IS adoption studies in the recent past, where authors (Alalwan et al. 2017; Alalwan et al. 2016; Chong 2013; Akturan and Tezcan 2012; Riffai et al. 2012) have extended well known IS adoption models such as TAM and UTAUT.

Table 4 RMSE for neural network model

Hidden Nodes	Training	Testing
1	0.122	0.145
2	0.101	0.127
3	0.112	0.131
4	0.121	0.149
5	0.117	0.151
6	0.125	0.142
7	0.101	0.129
8	0.106	0.128
9	0.138	0.157
10	0.123	0.132
Mean	0.117	0.139
Standard deviation	0.012	0.011

With regards to the fundamental constructs of TAM namely perceived ease of use and perceived usefulness, it was observed in the SEM results that perceived ease of use and perceived usefulness influences significantly behavioral intention of users towards mobile banking. The results imply that mobile banking users in Oman are not only interested in the usefulness of mobile banking services but also prefer the ease in its operations. The most likely explanation of this empirical evidence is the low maturity level of users towards mobile banking in this developing country. Akturan and Tezcan (2012) argued that the use of mobile banking helps to accomplish various financial tasks very quickly and is overall advantageous. Therefore, users develop a positive behavioral intention towards mobile banking services. They further argued that the effortless M-Banking transactions play significant role in motivating users to use more mobile banking services. It is also observed that mobile banking is useful for both banks and users since M-Banking helps banks to reduce the infrastructure cost while users get the round the clock

Table 5 Predictor importance

Predictors	Importance	Normalized Importance
Perceived Trust	.269	100.0%
Perceived Usefulness	.219	81.2%
Autonomous Motivation	.198	73.5%
Perceived Ease of Use	.177	65.7%
Controlled Motivation	.137	50.7%

facility. The results obtained in this study are consistent with many previous IS adoption studies (Davis 1989; Kim et al. 2007; Dai and Palvi 2009; Chang and Tung 2008; Chong 2013; Hanafizadeh et al. 2014; Chong et al. 2015; Liébana-Cabanillas et al. 2017).

The statistical results also support the causal relationship between the aforementioned cognitive constructs and behavioral intention to use M-Banking in Oman. The regression beta weight between autonomous motivation and behavioral intention was 0.216. This evidence implies that the M-Banking users in Oman have the desire to explore new technology. This enthusiasm or curiosity is one of the key factors for autonomous motivation. It is recommended to banks to identify groups of enthusiastic users and motivate them to use new services offered through M-Banking. Such motivating users may serve as the ambassadors of M-Banking facility to their relatives, peers, and friends. Controlled motivation with the beta value of -0.111 , is another antecedent influencing the behavioral intention towards M-Banking services in Oman. Creating the feeling of backwardness among users may reduce the negative influence of controlled motivation on behavioral intention. On the other hand, a positive technique may involve offering points and rewards to the mobile banking users to increase the user base. For example, the earned/ accumulated points or rewards should be able to generate free transactions and other advantages. Further, the peer pressure and social pressure can be used to motivate the customers to use M-Banking services. Introducing some customized plans or offers for college students and company employees will attract people to use M-Banking. For example, first 50 transactions through mobile banking are free. This can motivate them to try M-Banking and once they start using, it could motivate their friends, relatives, and colleagues to use the service.

It is interesting to note the results obtained from the two analytical models in Section 4. On the basis of the beta values obtained in structural models, the importance of antecedents can be summarized as follows from higher to lower: perceived trust, autonomous motivation, perceived usefulness, perceived ease of use and controlled motivation in terms of absolute values. The results obtained from neural network model were slightly different and ranking of predictors was as follows from higher to lower: perceived trust, perceived usefulness, autonomous motivation, perceived ease of use and controlled motivation. The main reason behind the change in the ranking of antecedents can be the nature of the relationship among decision variables. The neural network models detect linear as well as nonlinear relationships among decision variables whereas structural models detect linear relations only (Chong 2013; Sharma et al. 2016).

6.1 Theoretical implications

This study has mainly three theoretical implications. Firstly, this study used perceived usefulness and perceived ease of

use, the key antecedents of TAM as potential predictors of M-Banking acceptance. The results revealed that perceived usefulness and perceived ease of use are the significant predictors of M-Banking acceptance. The results are consistent with some information systems studies (Kim et al. 2007; Chong 2013; Liébana-Cabanillas et al. 2014; Liébana-Cabanillas et al. 2017). Secondly, this study extends the literature by extending TAM incorporating two cognitive constructs namely autonomous motivation and controlled motivation in the context of M-Banking acceptance. Some researchers (Bremer 2012; Zhou 2016) have explored the influence of cognitive constructs in the other domains of information systems such as MOOCs. There is no evidence in the extant literature where these cognitive constructs have been studied in the context of M-Banking, mobile commerce, etc. The results of this study reveal that autonomous motivation and controlled motivation have a positive and significant impact on the decision to use M-Banking services. Finally, integration of trust in the extended research model has added knowledge in the existing literature. We have developed a new research model with five predictors (perceived usefulness, perceived ease of use, controlled motivation, autonomous motivation, and trust), which have given a new dimension to the understanding of users' decision to accept M-Banking. This study fills the theoretical gap with this new research model, validating and testing with the help of an innovation methodology in two stages: structural equation modeling and neural network model.

6.2 Practical implications

This study can provide useful insights to the decision makers of telecommunication service providers, mobile banking app developers, and M-Banking service providers to enhance and maintain their customer base. The M-Banking services are in its initial stage in Oman, it is, therefore, essential for government and service providers to spread awareness about the benefits offered by this relatively new technology. The M-Banking technology has potential to change the way of life of people. Users can do a lot more with the help of this technology in comparison to the traditional banking. For example, users can get access to newly launched products without visiting physical location of banks. This study found that perceived usefulness of the M-Banking services influences the decision to adopt this technology along with its ease of operations. The developers of M-Banking apps need to focus on the development of the user-centric apps to create the perception of usefulness as well as ease in operations of users in their view. It will have a positive impact on the increase of M-Banking adoption rate.

With regard to increasing customer base, the autonomy of users has the significant influence on the decision to adopt M-Banking services from a developing country perspective. The

developers of M-Banking apps are advised to develop apps with the user-centric approach, which supports the users' autonomy (Guàrdia et al. 2013; Zhou 2016). With the help of such approach, Government and services providers can better understand the needs and motivations of M-Banking users. In addition to the cognitive constructs, trust is the key construct influencing the decision to accept M-Banking services. As mobile banking is a relatively new information communication technology, trust among customers is increasing slowly. To expedite the trust component among users, banking systems providing M-Banking services need to minimize the fear of users by providing multi-level security features. Mobile banking systems need to develop structural assurances to minimize the possible frauds and potential risks in the transactions of M-Banking (Gu et al. 2009). M-Banking service providers should develop different strategies for different demographics to enhance users' trust (Zhou 2012). For example, younger generation prefers to have higher quality information and services whereas older generation prefers to have structural assurances. The initial trust among users will increase the M-Banking services adoption. The findings of this study will help the decision makers in developing appropriate strategies to attract a high number of users to justify the cost incurred in the implementation of M-Banking systems (Hanafizadeh et al. 2014). To further boost the trust level among users, it is suggested to share about the data protection systems with users (Yadav et al. 2016; Liébana-Cabanillas et al. 2017). There should be a very well documented policy, known to users in case of transaction failure. In such cases, if money deducted from users' account should be refunded within a very short and fixed time period to motivate mobile banking users.

7 Limitations and future research

This study has a number of limitations that would pave way for future research. First, this study was cross-sectional, future research could be done to understand the behavioral intention in the longitudinal settings. Second, this research was

conducted in one of the Gulf Cooperation Council (GCC) countries. Therefore, it is recommended to conduct a comparative study between one developing and one developed country. Third, the research model in this study does not include the moderating effect of any variable. It is recommended to study the moderating effect of demographic variables as a future study for better understanding of mobile banking behavioral intention from a different segment of the population. Finally, the variance explained in the behavioral intention towards M-Banking by predictors was 65.4%, it suggests including additional variables such as mobility, involvement, and customization in the future research models.

8 Conclusion

Mobile banking is one of the latest innovative applications of mobile technologies in the recent times. Owing to the lower acceptance of mobile banking in Oman, this study realized the importance of understanding and examining key antecedents influencing mobile banking acceptance. Thus, a well-known technology acceptance model (TAM) developed by Davis (1989), was selected as the theoretical base to develop research model in this study. This study presented and tested a new research model with five potential independent variables namely perceived usefulness, perceived ease of use, autonomous motivation, controlled motivation, and trust to understand the users' behavioral intention towards the acceptance of mobile banking from a developing country perspective. In addition, this study explored the impact of these potential independent variables on the growth of the M-Banking industry in Oman, one of the prominent countries in the Middle-Eastern region. A two stage innovative methodology was employed, which is one of the many unique features of this study. In the first stage, structural equation modeling was employed to test the research hypotheses and in the second stage, neural network modeling was employed to rank the predictors influencing the behavioral intention of users towards M-Banking acceptance.

Appendix 1

Table 6 Descriptive statistics, Cronbach alpha, factor loading, and communalities

Indicators	Mean	Std. Deviation	Skew-ness	Kurtosis	Communalities	Factor loadings	Cronbach Alpha
TR1	4.18	1.191	-1.558	1.512	.831	.852	.948
TR2	4.40	1.221	-2.030	2.739	.898	.842	
TR3	4.32	1.219	-1.820	2.144	.915	.864	
TR4	4.06	1.207	-1.311	.813	.828	.809	
PEOU1	3.55	1.129	-.370	-.856	.809	.856	.906

Table 6 (continued)

Indicators	Mean	Std. Deviation	Skew-ness	Kurtosis	Communalities	Factor loadings	Cronbach Alpha
PEOU2	3.75	1.131	−.702	−.359	.881	.863	
PEOU3	3.69	1.221	−.642	−.583	.854	.842	
PU1	3.43	1.029	−.508	−.316	.780	.817	.857
PU2	3.39	.971	−.546	.082	.795	.862	
PU3	3.44	.990	−.457	−.224	.780	.836	
AM1	3.51	1.044	−.433	−.415	.823	.857	.885
AM2	3.59	.974	−.553	−.195	.863	.859	
AM3	3.44	1.030	−.295	−.434	.774	.844	
CM1	2.42	1.115	.948	.261	.845	.898	.929
CM2	2.32	1.196	1.011	.183	.910	.918	
CM3	2.44	1.305	.785	−.505	.893	.933	
BI1	3.87	1.242	−.996	.018	.939	.969	.969
BI2	3.82	1.270	−.997	−.017	.951	.975	
BI3	3.82	1.260	−.949	−.098	.935	.967	

Appendix 2

Table 7 Survey items

Constructs	No	Items	References
Perceived Trust	TR1	I trust in M-Banking.	Alalwan et al. (2017); Liébana-Cabanillas et al. (2017), Lin (2011)
	TR2	I think M-Banking is trustworthy.	
	TR3	M-Banking transactions are safe.	
	TR4	M-Banking transactions are reliable.	
Perceived Ease of use	PEOU1	It is easy to use M-Banking.	Wang et al. (2009); Davis (1989)
	PEOU2	Learning to use M-Banking is easy.	
	PEOU3	M-Banking is understandable and clear.	
Perceived Usefulness	PU1	M-Banking improves my work performance.	Liébana-Cabanillas et al. (2017); Davis (1989)
	PU2	M-Banking improves my productivity.	
	PU3	Overall, M-Banking is useful.	
Autonomous Motivation	AM1	I enjoy M-Banking usage.	Zhou (2016)
	AM2	M-Banking is a pleasurable activity.	
	AM3	M-Banking is beneficial to me.	
Controlled Motivation	CM1	I use M-Banking because others are using.	Zhou (2016)
	CM2	I feel pressure to use M-Banking from my family.	
	CM3	Not using M-Banking makes me uncomfortable.	
Behavioral Intention	BI1	I plan to use M-Banking in the future.	Liébana-Cabanillas et al. (2017)
	BI2	I intend to continue to use M-Banking.	
	BI3	I will use M-Banking for banking activities.	

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