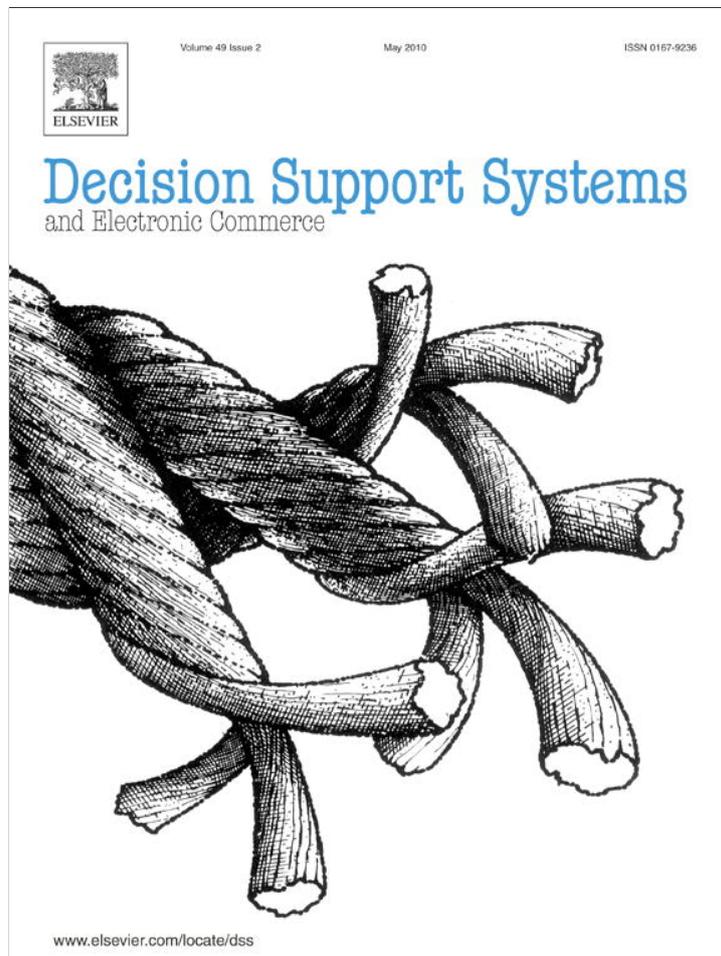


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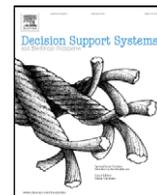
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Examining multi-dimensional trust and multi-faceted risk in initial acceptance of emerging technologies: An empirical study of mobile banking services

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ABSTRACT

The factors affecting rejection or acceptance of an emerging IT artifact such as mobile banking have piqued interest among IS researchers and remain unknown due in part to consumers' trust and risk perceptions in the wireless platform. This study extends this line of research by conjointly examining multi-dimensional trust and multi-faceted risk perceptions in the initial adoption stage of the wireless Internet platform. Results of this study indicate that risk perception, derived from eight different facets, is a salient antecedent to innovative technology acceptance. Beyond prior studies, the results also provide empirical support for employing personal trait factors in analyzing acceptance of emerging IT artifacts.

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1. Introduction

In the last decade, the convergence of the Internet, wireless technologies, and mobile devices has made possible mobile commerce (m-commerce), a new paradigm of an emerging information technology (IT) artifact. In m-commerce, money has become bits of data stored in mobile devices and moved as bytes of information in the form of e-cash. As an extension of e-commerce, m-commerce has inherently provided greater flexibility and mobility in such domains as healthcare, location services, quality control, and investment [1,11,36,68,69,81,89]. It is, consequently, becoming an inseparable part of today's business arena and thereby changing the way personal financial services are designed and delivered as well as the way people interact with other societal constituents, such as retail banks. Mobile banking (MB) is an innovative method for accessing banking services via a channel whereby the customer interacts with a bank via a mobile device (e.g., mobile phone or personal digital assistant). MB offers a great deal of promise in its ability to provide anywhere–anytime banking. With MB, customers and decision-makers can access multiple banks, accounts, and financial services [1].

The topic of the diffusion of innovative IT artifacts has piqued interest among researchers. Similar to other innovative technologies, MB is facing adoption barriers while in its infancy stage. Prior research has indicated that factors including technological advances, better understanding of technology, and more tech-savvy consumers make today's environment ripe for MB [31]. However, the acceptance or rejection of the artifact is still in doubt. As m-commerce continues to struggle to find widespread consumer adoption [88], MB inevitability confronts such challenges as consumers' trust in the new wireless technology and their perception of risk associated with the open airwaves of a wireless medium. We thus argue that consumers' trust and risk perception may influence their acceptance of MB services. Motivated by recent research that suggests manifold dimensionalities for risk and trust and the integral studies on trust versus risk in new IT contexts [26], we believe that timely initiatives on emerging IT artifacts like this study may help explain how trust and risk perceptions might affect the eventual diffusion of innovative technologies. We further suppose that the literature associated with e-commerce may offer insights into innovative technology acceptance because of the congruence in terms of human users facing e-commerce systems.

The objective of this research is to reveal mechanisms associated with the formation of behaviors related to acceptance of MB services. One general research question drove this study: How do multi-dimensional trust and multi-faceted risk perceptions at the individual

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level influence the acceptance of emerging innovative technologies? Our approach diverges from the majority of prior research that examines the impact of risk and trust on individual behavior. Prior research typically tests trust as a single construct [4,18,39,51] or investigates trust constructs and risk dimensions disjointedly [5,56]. Drawing on research in marketing [20,67] and information systems [22,27,64,65], we argue that multi-dimensional trust constructs may collectively play a crucial role in individual behavior toward adopting an innovative IT artifact, especially in the early adoption stage. We also posit that risk perception, in the same vein, should be examined from multi-faceted approaches, and that it is of interest to study risk perception along with multi-dimensional trust in a new IT phenomenon.

Therefore, our research model contributes to the literature by incorporating the integral roles of trust and risk into innovative technology acceptance. In addition to extending previous research on technology acceptance, we specifically study multi-dimensional trust constructs including trust belief, disposition to trust, and structural assurance. Prior research has incorporated perceived risk as a key antecedent of behavioral intention toward e-commerce purchases [22,40]; the current study extends this body of research by expanding this construct to eight facets including performance, financial, time, psychological, social, privacy, physical, and overall risk. We believe that this study can theoretically contribute to IS literature relating to trust, risk, and emerging IT artifact acceptance. In addition, this study can pragmatically inform MB service providers of how individuals interact with innovative technology so that providers can assess and cultivate trust and reduce risk perception toward the eventual adoption. We expect this study to offer instrumental insights to traditional brick-and-mortar and web-based banks before they migrate to the new m-commerce model.

The remainder of this paper is organized as follows. We first revisit the literature related to MB adoption. The theoretical bases of the study are described next. Trust, risk, self-efficacy, and the Unified Theory of Acceptance and Use of Technology (UTAUT) are the foundation for the theoretical model of the study. Eight risk dimensions and three trust constructs are expanded and incorporated into the model, and specific hypotheses are developed. Self-efficacy and its relationship to trust and risk constructs are examined. The research methodology and the data analysis using structural equation modeling are presented next. The paper concludes with a discussion of results, contributions to theory and practice, limitations, and suggestions for future research.

2. Literature review

In this section, we revisit the technological development of MB and discuss prior studies related to the adoption of MB services.

2.1. Mobile banking

The banking industry is among the leading sectors in adopting the Internet and mobile technology for consumer markets [47]. Today, the banking industry shares the common characteristics of a high-technology industry: competitive volatility, market uncertainty, and technology uncertainty [78]. According to Oh and Lee [72], before the advent of Internet banking, banks had long invested in information technologies, and the operation of banks was mostly accomplished electronically with successful experience in development systems such as ATMs and phone banking. The emergence of the Internet had a significant impact on the diffusion of electronic banking, which is seen as one of the most successful business-to-consumer (B2C) applications in e-commerce. Electronic banking has changed the business of retail banks significantly in terms of cost reduction and increased convenience for the customer [46,47].

In recent years, innovative technology has become an increasingly vital element in the competitive landscape of the financial service segment as the rapid development of electronic banking services via multiple electronic channels has made it possible to create new kinds of added value for customers [16,85]. The technological revolution has reshaped the sociotechnical interaction between banking service providers and consumers and has created more opportunities for service consumption, as customers have become less willing to visit traditional branches, more receptive to new electronic channels, and more sophisticated in demanding better service quality including 24-hour service availability [85].

While technologies, such as 2.5G (i.e. GPRS), 2.75G (i.e. EDGE), and 3G wireless networks that support faster and easier access to the Internet, have become increasingly ubiquitous and thereby changed consumers' behavioral patterns in interacting with their financial institutions, consumers are more technologically savvy than ever, which has reduced their uneasiness involving technological innovation [30,72]. With the infusion of innovative technologies in the financial services sector, the rapid spread of Internet-enabled mobile phones and PDAs has made the transformation of banking applications to mobile devices a logical evolution of electronic banking. In order to maintain and potentially create a competitive advantage, banks are continually attempting to expand the capabilities of their services.

Consequently, as Internet banking edges further into the mainstream of banking services, financial institutions are leading the way into the next technological frontier: mobile access [60]. This newly-emerging channel for delivering financial services via mobile devices has created the inception of mobile banking, which can be implemented through such technological means as downloadable applications, mobile browsers, text messaging, and preloaded applications.

2.2. Mobile banking adoption

We believe that the literature associated with e-commerce, particularly Internet banking, may offer valuable insights into innovative mobile banking acceptance because of the congruence in terms of human users facing e-commerce systems, although differences exist in customers' perception of their value [47,48]. A plethora of prior studies, such as Nor and Pearson [70] and Nor et al. [71] as well as Kim et al. [40], have investigated the key constructs contributing to the acceptance of Internet banking and found that risk and the multidimensionality of trust play a vital role. In addition, their work proved that such key constructs as social norms, perceived usefulness, perceived ease-of-use, attitude, and self-efficacy, can also be applied in the Internet banking domain. In the extended domain of mobile banking, previous studies have attempted to examine the demographic characteristics of consumers and to find the market segments for MB adopters and non-adopters. Age, gender, education, and income level have been studied. For example, Mattila [62] surveyed over 1300 Finnish bank customers and found that MB adopters and non-adopters show different socio-demographic characteristics. Adopters are relatively young, with the majority in the age group of 25–34. They are mostly white collar workers and students with average income levels. Likewise, Laforet and Li [45] found that mobile bank adopters in China are relatively young, wealthy, and employed.

Although demographic characteristics help identify potential mobile banking adopters, the question of why people adopt or do not adopt mobile banking cannot be answered solely by socio-demographic information. Determinant factors suggested by the diffusion of innovation model, the Theory of Planned Behavior (TPB), the Technology Acceptance Model (TAM), and other related constructs have been studied to explain MB adoption behaviors.

As MB services offered via a mobile media channel are still new to customers, some researchers have found Rogers' diffusion of innovation model relevant [53,62]. According to the diffusion of innovation model, consumers' perception of the product/service's innovative attributes,

including relative advantage, complexity, compatibility, observability, and trialability, affect their adoption behavior. Based on survey data and descriptive data analysis, Mattila [62] revealed that the major trigger of adoption behavior is availability of mobile services regardless of time and locations (one of the relative advantages of m-commerce); the major hindrances to adoption are the malfunction of services and lack of guidance [32]. Lee et al. [53], using qualitative methods, found that innovative attributes are related to consumers' attitudes toward adoption. Both Lee et al. [53] and Mattila [62] discussed the importance of perceived risk on adoption behavior. Lee et al. [53] also found Jacoby and Kaplan's six risk dimensions [33] relevant to adoption behavior in the MB context.

In order to better predict adoption behavior, Brown et al. [10] applied Tan and Teo's Internet banking adoption framework to the MB context. Tan and Teo [86] had combined the diffusion of innovation theory and TPB to explain intention to adopt Internet banking. Their study revealed that relative advantage, compatibility, trialability, perceived risk, perceived self-efficacy, and government support of Internet commerce are significant determinants. Brown et al. [10] found perceived relative advantage, trialability, the number of banking services required, and perceived risk to be significant factors affecting MB adoption. The risk construct in their study is limited to information risk and security concerns.

Based on TPB and TAM literature, Luarn et al. [57] proposed an MB acceptance model and introduced the construct "perceived credibility" into the m-commerce context. Perceived credibility is considered related to, but different from, perceived risk and trust constructs. It refers to the extent to which a person believes that using MB will have no security or privacy threats. They found that perceived credibility has a stronger influence on behavior intention than do other factors, although perceived usefulness and perceived ease-of-use are strong predictors; perceived self-efficacy and perceived financial cost, including fees paid for MB services and money spent on mobile devices and communication time, have some influence on behavioral intention.

Kim et al. [41] and Kim et al. [40] approached the problem from a more focused perspective: the formation of consumers' initial trust in MB. Their studies confirmed that initial trust is a significant determinant of MB adoption intention. Factors that help form initial trust include the relative advantage of MB over other banking channels, personal propensity to trust new technology and new business partners, and perceived structural assurance offered by mobile banking firms.

Lee et al. [52] also studied the effect of trust on MB adoption but included a perceived risk construct under the umbrella of TAM. They proposed that adoption behavior is influenced by trust, perceived risk,

and perceived usefulness. Different trust dimensions (trust in bank, telecom provider, and wireless infrastructure) and different risk dimensions were examined. Their results indicate that both trust and perceived usefulness have a significant, direct impact on adoption behavior while the impact of perceived risk is only mediated by trust.

Based on recent research in MB which has confirmed perceived risk and trust as important factors influencing adoption behavior, this research extends the study of these two factors by examining different dimensions of perceived risk, different trust constructs, and their interactions.

3. Conceptual background and hypotheses development

In this section, we elaborate on the theory base, including multi-dimensional trust, multi-faceted risk perception, self-efficacy, and technology acceptance, and derive the hypotheses and the research model shown in Fig. 1 below.

3.1. The importance of trust in mobile banking

Trust plays a central role in exchange relationships involving unknown risks [27,34]. The role of trust is especially critical in the online shopping environment, which has been described as the "wild wild west" of the 21st century [65]. There are no guarantees that vendors will not behave opportunistically at the expense of online shoppers. With respect to the adoption of wireless banking, consumers face similar situations and need to rely on trust to overcome their risk perceptions. The potential risks may come from multiple sources such as the vulnerability of wireless and Internet communication platforms and the technical capability of banks.

3.2. Definition of trust

In this study, following the call from Gefen et al. [26] for further studies on trust in new IT phenomena, we conjointly examine three dimensions of trust based on the trust topology suggested by McKnight et al. [64]: disposition to trust, structural assurance, and trust belief. Disposition to trust, from the perspective of trust attributes, is defined as a general inclination in which people show faith or belief in humanity and adopt a trusting stance toward others [65]. Disposition to trust is people's general tendency to trust others [65] and can be considered one type of personal trait. Structural assurance (SA) is the trust perception about the institutional environment [65]. In the context of mobile banking, SA is the perception about the availability of the necessary legal and technical

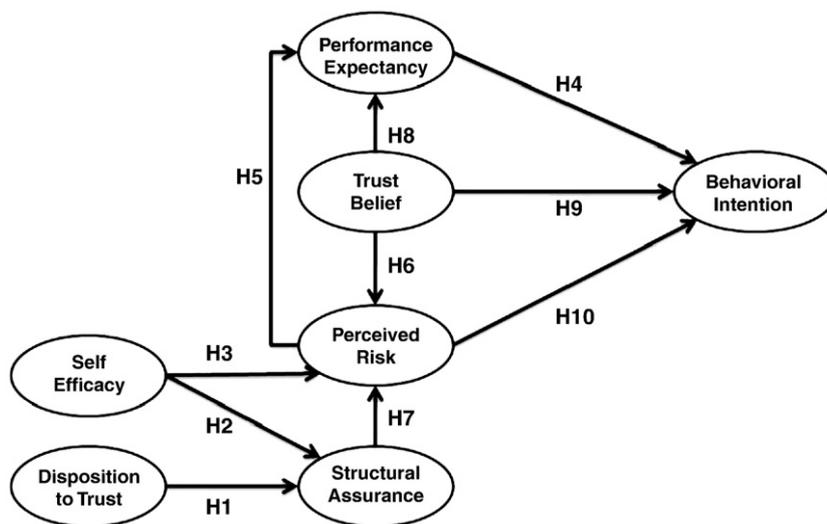


Fig. 1. Research model.

structures such as encryption, promises/guarantees, insurances, regulations, or other procedures in the wireless Internet to ensure the successful completion of financial transactions with a bank. Trust belief is the perception that the trustworthiness of the vendor consists of a set of specific beliefs about integrity, benevolence, and competence [27,65].

3.3. Relationships among trust constructs

Unlike traditional banking, MB is conducted through the wireless Internet. It is necessary to distinguish between trust beliefs about a bank and trust in the wireless Internet as a platform for financial transactions. In this study, we focus on factors that drive existing customers of a bank to further adopt recently-introduced wireless banking services. Therefore, for our research context, vendor-specific trust beliefs are one type of pre-existing trust, different from initial trust beliefs, which are formed when customers interact with a bank for the first time. On the other hand, trust in the wireless Internet as a platform for financial transactions is one type of initial trust because wireless banking is new to the majority of customers.

The distinct maturity stages of these two types of trust provide important insights into the relationships among disposition to trust, structural assurance, and trust belief. Previous research has confirmed that disposition to trust has a salient and direct effect on the formation of initial trust [25,63,66]. The association between disposition to trust and the formation of initial trust is based on either the individual's personal faith in humanity or the individual's strategy for dealing with others [38,64]. In the same vein, in the absence of more specific knowledge about the wireless Internet as a viable channel for financial transactions, an individual user with a generally higher tendency to trust others will also have higher initial trust in the context of mobile banking. Because of the lack of physical proximity in the wireless banking setting, disposition to trust has an essential impact and direct effect on the formation of initial trust. In an unfamiliar or new situation, potential users who have insufficient information may vary in their readiness to trust wireless banking facilities in the open airwaves.

3.4. Disposition to trust and structural assurance

Disposition to trust is especially important for the formation of initial trust and becomes less important for established trust relationships or pre-existing trust beliefs [27]. For existing customers, their trust beliefs in the bank have already formed and are based upon concrete knowledge regarding the integrity, benevolence, and competence of the bank. Disposition to trust has little influence over such pre-existing trust built upon solid knowledge. Similarly, trust in the wireless Internet, as one type of trust in an initial formation stage, is also expected to exert little influence over the established trust beliefs in a bank. Thus, for relationships among the three trust constructs, we focus on the impact of disposition to trust on structural assurance. In the presence of minimal or no experience in using the wireless Internet as a platform for financial transactions, disposition to trust is expected to color people's trusting perception in the wireless Internet. Those with high disposition to trust are more likely to feel comfortable or safe with using the wireless Internet for financial transactions. Therefore, we posit that

H1. Disposition to trust has a positive impact on structural assurance.

3.5. Self-efficacy

Originating from Social Cognitive Theory as proposed by Bandura [7], self-efficacy is defined as *a person's perception of how easy or difficult it would be to carry out a behavior*. It refers to people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives [2,3]. In the arena of Information Systems, self-efficacy is important in understanding individual responses to information technology. In this

research, the focus is on whether end users believe they have the required knowledge, skill, or ability to use mobile banking services. Therefore, applied in the context of mobile banking, self-efficacy refers to the users' judgment of their capability to adopt mobile banking. Schwarzer [80] stated that self-efficacy is the belief that one can perform a novel or difficult task, or cope with adversity in various domains of human functioning. Moreover, self-efficacy can affect human functioning in terms of choices regarding behavior, motivation, thought patterns and responses, and the idea of destiny [7]. In this research, it is posited that potential customers with a higher level of self-efficacy will have higher trust perception of the institutional environment. Thus, we hypothesize that

H2. Self-efficacy is positively associated with structural assurance.

3.6. Definition and components of perceived risk

Bauer introduced the concept of perceived risk (PR) and defined PR as *a combination of uncertainty plus seriousness of outcome involved* [8]. Cunningham then measured PR in terms of certainty and consequences [17]. Thereafter, much research has applied PR to consumer behavior studies and further identified the multi-dimensional nature of the perceived risk construct [24,33,37,73]. In a more relevant study, Featherman et al. [22] empirically tested the effects of seven facets of PR including performance, financial, time, psychological, social, privacy, and overall risk in the context of Internet-delivered e-service adoption. This research extends their PR model to the study of an emerging IT artifact (i.e., MB). In addition to the above seven facets, possible health risk, e.g., brain tumors, related to long-term cell phone usage has been discussed in the news. Although the majority of scientific publications show that cell phone is safe, public concerns of potential physical risk have increased [15]. Since cell phone is essential for people receiving MB services and conducting MB activities, perceived physical risk related to cell phone usage is considered relevant and included in our PR dimension.

3.7. Perceived risk in mobile banking

Internet banking and MB are prone to similar risks [53]; the difference is in the information communication channels. Some researchers even investigate Internet banking and MB jointly [45]. Previous Internet banking research identifies PR as an important attitudinal factor that influences adoption behavior [43,45,50,77,86], but PR investigation is mainly focused on transaction security risk or privacy risk. Lee et al. [53] argued that Jacoby and Kaplan's risk dimensions model [33] is relevant and appropriate to MB study. Featherman et al. [22] empirically tested such a risk model in the context of Internet-delivered e-service adoption, with the adjustment of replacing the physical risk dimension with privacy risk, which is a more evident risk factor in e-service. This research adopts the risk dimensions proposed by Featherman et al. [22] and further advances the study on PR by including physical risk. Table 1 shows the several facets of risk perception and their corresponding definitions.

3.8. Perceived risk and self-efficacy

Perceived risk, people's perceptions about their susceptibility to various threats, is often theorized as a cause of self-protective behavior. To certain extent, such effect of perceived risk could be counteracted by people's self-efficacy or confidence in their ability to exert personal control. Kim et al. [44] provided evidence that self-efficacy is negatively associated with perceived risk in the B-to-C e-commerce environment. People with a high level of self-efficacy are more certain that they will make the right purchasing decisions. Even if something goes wrong with the transaction, they feel confident about solving the problems in their favor. In the context of MB, we posit that people with a high level of self-efficacy will perceive lower uncertainty or less loss from difficult

Table 1
Multi-faceted risk perception and definitions.

Risk facets	Definition
Performance risk	"The possibility of the product malfunctioning and not performing as it was designed and advertised and therefore failing to deliver the desired benefits." [22, p.455]
Financial risk	"The potential monetary outlay associated with the initial purchase price as well as the subsequent maintenance cost of the product. The current financial services research context expands this facet to include the recurring potential for financial loss due to fraud" [22, p.455]
Time risk	"Consumers may lose time when making a bad purchasing decision by wasting time researching and making the purchase, learning how to use a product or service only to have to replace it if it does not perform to expectations." [22, p.455]
Psychological risk	The risk that the service will lower the consumer's self image. [33]
Social risk	The risk that using a product or service may lead to embarrassment before one's social group. [33]
Privacy risk	"Potential loss of control over personal information, such as when information about you is used without your knowledge or permission." [22, p.455]
Physical risk	The risk to the buyer's or other's safety in using products. [33]
Overall risk	"A general measure of perceived risk when all criteria are evaluated together." [22, p.455]

situations, e.g. potential fraud or transaction errors. Therefore, we test the following hypothesis:

H3. Self-efficacy is negatively associated with perceived risk.

3.9. Performance expectancy

In composing their Unified Theory of Acceptance and Use of Technology (UTAUT), Venkatash et al. [90] proposed a unified model integrating acceptance determinants across several competing models. According to UTAUT, intention to use the information technology can be predicated by three antecedents: performance expectancy, effort expectancy and social influence and, as a consequence, intention to use is to exert influence on actual behavior toward IT adoption with facilitating conditions. Performance expectancy is defined as *the degree to which an individual believes that using the system will help him or her to attain gains in job performance* [90]. The concept of performance expectancy has been considered the most powerful tool for explaining the intention to use the system regardless of the type of environments, mandatory or voluntary. Therefore, based on this theoretical underpinning, we propose that

H4. Performance expectancy is positively associated with behavioral intention to adopt mobile banking.

3.10. Perceived risk and performance expectancy

Performance expectancy measures how useful people perceive a system, such as the Internet or mobile technology, to be in achieving their goals in terms of job performance. Featherman et al. [22] propose that the performance expectancy of the to-be-adopted system is negatively affected by perceived risk. Uncertainty and potential loss, both related to perceived risk, may impede the favorable evaluation of the to-be-adopted system. Environmental uncertainty is inherent in the wireless medium due to the unpredictable nature of Internet and wireless technologies, which are often beyond the control of the individual user. In essence, a high level of risk perception is associated with behavioral and environmental uncertainty pertaining to potential threats and losses, which in turn affect the development of an individual's cognitive recognition about the usefulness of mobile banking services. Therefore, it follows that

H5. Perceived risk is negatively associated with performance expectancy.

3.11. Perceived risk and trust belief

Trust belief has been found helpful in explaining how consumers may overcome perceived risk and engage in online transactions [34,59]. Trust plays a critical role in mitigating perceived risks, especially for transactions involving uncertainty [34]. Because MB is still in the initial adoption stage, consumers are unclear about the

technical capability of their banks to provide MB service and about the reliability and security of the Internet and wireless communication channels in delivering their sensitive financial data, among other concerns. The *existing* trust beliefs toward a bank are relied on as one of the major leverage points for consumers to assess the potential risks involved in the wireless banking service provided by that bank. Consumers who believe in the technical capability, integrity, and benevolence of their banks are more likely to overcome their risk perceptions toward new services such as the wireless banking situation. Therefore, considering the uncertainties in MB, the stronger the trust a consumer has toward a bank, the lower the risk he or she anticipates in adopting mobile banking. We posit that

H6. Trust belief toward a bank will have a negative effect on perceived risks in mobile banking.

3.12. Perceived risk and structural assurance

Online transactions, in general, raise security and privacy concerns among users [87]. Similar to trust belief, structural assurance such as promises, guarantees, and contractual protections should also help alleviate consumers' perceived risk in the unfamiliar, open airwave environment. MB service providers can draft customer service policies, use advanced encryption technologies, and make promises (e.g. 100% satisfaction guarantee, monetary refund, protection of privacy, and accurate transaction information) to relay structural assurance information to MB users. As such, consumers who trust the legal and technology structures of the wireless Internet will be more likely to believe their financial data will be protected against loss or theft along transmission. Such belief in the structural soundness of the wireless Internet platform is anticipated to lower the perceived risk in wireless banking. Therefore, we posit that

H7. Structural assurance has a negative impact on perceived risk.

3.13. Trust belief and performance expectancy

Besides the role of mitigating risks, trust belief also enhances an individual's expected usefulness or performance of a product or service [27]. To a certain extent, trust acts as a type of subjective guarantee, ensuring that a customer will receive the expected benefits or usefulness from an exchange relationship. If a bank cannot be trusted in providing MB service, consumers are more likely to suffer a loss from using MB when the bank behaves opportunistically. As a result, there is no reason for them to expect any utility from using the MB services provided by that bank. Considering the initial adoption stage of wireless banking, the *existing* trust belief in a bank serves as an important basis for a customer to judge whether the mobile banking services of that bank can be successfully conducted and of any utility to him or her. Therefore, we posit that

H8. Trust belief has a positive impact on performance expectancy.

3.14. Trust/risk beliefs and behavioral intention

According to the trust literature, trust/risk beliefs are two key determinants of people's behavioral intention to conduct activities involving risk. For example, Gefen et al. [27] showed that trust belief increased one's behavioral intention to buy books or CDs from an online vendor. Jarvenpaa and Tractinsky [34] provided empirical evidence that risk perceptions reduced online shoppers' behavioral intention to purchase books. Malhotra et al. [59] showed that both trust belief and risk belief significantly drive one's intention to release personal information through the Internet. Similarly in the context of mobile banking, consumers with favorable trust perceptions toward their banks are more likely to try the bank's new mobile banking services. On the other hand, those with high risk beliefs toward mobile banking will be cautious about losing control over their confidential information or incurring other types of losses and be hesitant to try mobile banking services. Therefore, in the context of mobile banking, consumers' behavioral intention to adopt mobile banking is expected to be enhanced by higher trust belief toward a bank and/or lower risk perception toward wireless banking.

H9. Trust belief toward a bank will have a positive effect on consumers' behavioral intention to adopt mobile banking.

H10. Perceived risk toward mobile banking will have a negative effect on consumers' behavioral intention to adopt mobile banking.

4. Research methodology

4.1. Study design and procedures

A survey methodology was used to examine the research model. Undergraduate student volunteers at an Eastern U.S. university were recruited as subjects for this study. All of these subjects have used the Internet for more than one year and 90% of them have used cell phones for more than one year. Also, undergraduate students often have convenient access to the Internet and the basic computer skills required for conducting various online activities such as online shopping and online account management. Therefore, they have the basic computer skills and the necessary technology infrastructure to conduct mobile banking, which relies on the integration of wireless and Internet technologies. In addition, these student subjects represent a natural part of the population of interest, i.e. potential mobile banking adopters. In fact, prior studies have found that adopters of mobile banking have some intermediate education and are generally younger, as younger customers tend to perceive lower risks in mobile banking than mature customers and are less resistant to changing their habits to perform financial transactions [49,85]. Therefore, we believe that student subjects are among the potential adopters of mobile banking. The request to participate in the study was announced to about 180 undergraduate students enrolled in general business core courses. As an incentive for participation, respondents received extra credit accounting for about 1% of their total grade. A total of 122 usable responses were received (56 males and 66 females) and used in our data analysis. The age of the subjects ranged from 18 to 34 with an average of 21.

4.2. Measurement development

Most of the instruments were drawn from previous research and re-worded accordingly for our research context, i.e., mobile banking. Disposition to trust was measured using four items by Gefen and Straub [28]. Structural assurance was measured by four items from McKnight et al. [65]. Trust belief was measured by items developed by Gefen et al. [27]. Self-efficacy was measured using three items by Gist and Mitchell [29]. Performance expectancy and behavioral intention

were measured using items from Venkatesh et al. [90]. Seven dimensions of perceived risk (performance risk, financial risk, time risk, psychological risk, social risk, privacy risk, and overall risk) were adapted from those by Featherman et al. [22]. The instrument for physical risk was designed especially for this study. All these core constructs were measured using five-point Likert scales.

4.3. Covariates

Four covariates that might influence behavioral intention to adopt mobile banking services were included in this study as control variables for predicting intention to adopt such services. They are gender, age, Internet experience, and computer experience.

5. Data analysis

Partial Least Squares (PLS), a component-based structural equation modeling (SEM) technique, was employed to examine our measurement model and test the proposed hypotheses. There are several reasons to use the PLS technique. First, PLS has less strict requirements on sample size and residual distributions than covariance-based SEM techniques such as Lisrel and AMOS [14]. Second, statistical identification with formative models is difficult for covariance-based SEM techniques but is not an issue for PLS [12,75]. In this study, perceived risk is treated as a second-order formative construct instead of being a reflective construct as in the study by Featherman et al. [22]. Here, formative representation is preferred over reflective because the increase in one risk dimension such as perceived social risk does not necessarily cause an increase in other types of perceived risks (performance risk, financial risk, etc.). Third, PLS is well-suited for studies in the early stage of theory building and testing [35]. Thus the PLS technique is well-suited for our research context, as the adoption of wireless banking services is still largely unexplored or under-explored research area. Fourth, PLS is especially capable of testing large, complex models with latent variables and "is virtually without competition" [91 p. 590]. Our research model is fairly large and complex, including a large number of variables and both reflective and formative constructs. Therefore, PLS is considered more appropriate for this study than covariance-based SEM techniques.

The following subsections describe a two-stage approach to test our measurement model and research hypotheses. Before testing our hypotheses, we first demonstrate the soundness of our measurement by examining the issue of common methods variance, the test of second-order factors, and the CFA results.

5.1. Common methods variance

Common methods variance (CMV) can be a major source of measurement error for survey studies, especially when variables are latent and measured using the same survey at one point in time. CMV could potentially inflate the true correlations among latent constructs and threaten the validity of our conclusions. To check the extent of CMV, we first examined the correlation matrix among latent constructs. We found that only low to moderate correlations exist among those latent constructs, indicating the minimal influence of CMV. Harman's single-factor test was further used to assess the extent of CMV [76]. CMV is present if the factor analysis results in a single factor or if one general factor accounts for more than 50% of the covariance. All items in our measurement model were first entered simultaneously into an exploratory factor analysis, which yielded fourteen factors with an eigenvalue above one. The first factor accounts for 22.5% of the variance and all fourteen factors account for 73.5% of the total variance. Then, the initial solution was rotated using a varimax rotation in principal component analysis. After rotation, each factor accounts for less than 8% of the total variance. All these tests confirm that CMV is not a major concern in this study.

5.2. Test for second-order factors in multi-faceted risk perception

Second-order factors can be approximated using multiple approaches [14]. One commonly-used approach is the repeated indicator approach, also known as the hierarchical component model [55]. A second-order factor is directly measured by using items of all its lower-order factors. The repeated indicator procedure works best when the lower-order constructs have about equal numbers of indicators. The second commonly-used approach is to model the paths between lower-order and higher-order factors [21]. In PLS, this approach is implemented by measuring a second-order factor using the scores of its first-order factors. In this study, we used the latter approach because the eight dimensions of perceived risk have different numbers of indicators, ranging from two to five.

The measurement quality of the formative second-order factors was tested following the suggestions by Chin [12] and Diamantopoulos et al. [19]. We first examined the correlations among the eight first-order perceived risks. The absolute correlations among these eight first-order factors vary from 0.06 to 0.62 and the average is 0.32. This result suggests that perceived risk is better represented as a formative second-order factor instead of a reflective one since a reflective second-order construct would show extremely high correlations among its first-order factors (often above 0.8) [74].

We further assessed the strength of the relationship between perceived risk and its eight first-order risk dimensions. All first-order risk dimensions except social and physical risks were found to have significant path coefficients (or PLS weights) (Fig. 2). The variance inflation factor (VIF) was then computed for these first-order risk factors to assess multicollinearity. VIF values above 10 would suggest the existence of excessive multicollinearity and raise doubts about the validity of the formative measurement [19, p. 272]. The VIF values varied from 1.1 to 2.5 for these eight first-order factors. Therefore, multicollinearity is not a concern in this study.

According to Mathieson et al. [61], formative constructs are allowed to contain non-significant indicators, especially in the absence of multicollinearity. Retaining insignificant indicators is a recommended practice [9,58] as indicators in a formative construct are not interchangeable and may be very different. Dropping insignificant indicators may omit a unique part of the content domain, i.e. compromising the content validity of the construct. Therefore, to ensure the content domain of the perceived risk of mobile banking, we kept all eight first-order risk dimensions, including non-significant ones, in the following data analysis.

5.3. Measurement model assessment

All first-order factors in our research model are reflective constructs. The measurement quality of these reflective instruments was assessed based on their convergent validity, reliability, and discriminant validity. Convergent validity is suggested if factor loadings are 0.60 or higher [6]. All indicators had loadings equal to or above 0.6 except two items used to measure perceived performance risk. One of these two items has a loading above 0.5, which, according to Chin [13], is considered acceptable. Therefore, only one item measuring performance risk was dropped and not included in the subsequent analysis. All remaining indicators exhibit sound convergent validity (Table 2). We then examined the reliabilities of all latent constructs using composite reliability (CR) and average variance extracted (AVE). A scale is considered reliable if it has CR above 0.7 and AVE above 0.5 [6]. As shown in Table 2, all the scales were reliable. To access discriminant validity, we examined both a loading and cross-loading matrix (Table 2) and a correlation matrix (Table 3). In the loading and cross-loading matrix, all measurement items should load more strongly on their respective construct than on other constructs. Second, in the correlation matrix, the square root of the AVE of each construct should be higher than the inter-construct correlations, i.e. the correlations between that construct and any other constructs [23]. As shown in Tables 2 and 3, all constructs in our model satisfy these two criteria for discriminant validity. Therefore, our measurement model exhibits the sound reliability and validity necessary for further testing of our research hypotheses.

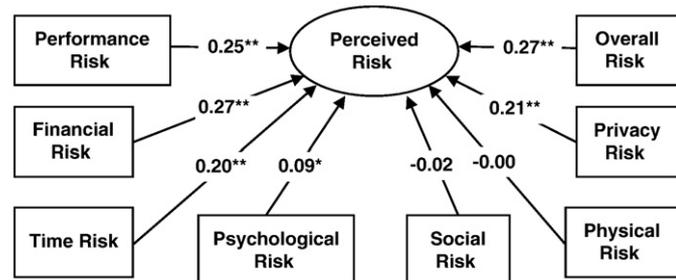


Fig. 2. PLS results for the relationship between perceived risk and its eight first-order risk perception factors. * significant at 0.05 level; ** significant at 0.01 level.

performance risk. One of these two items has a loading above 0.5, which, according to Chin [13], is considered acceptable. Therefore, only one item measuring performance risk was dropped and not included in the subsequent analysis. All remaining indicators exhibit sound convergent validity (Table 2). We then examined the reliabilities of all latent constructs using composite reliability (CR) and average variance extracted (AVE). A scale is considered reliable if it has CR above 0.7 and AVE above 0.5 [6]. As shown in Table 2, all the scales were reliable. To access discriminant validity, we examined both a loading and cross-loading matrix (Table 2) and a correlation matrix (Table 3). In the loading and cross-loading matrix, all measurement items should load more strongly on their respective construct than on other constructs. Second, in the correlation matrix, the square root of the AVE of each construct should be higher than the inter-construct correlations, i.e. the correlations between that construct and any other constructs [23]. As shown in Tables 2 and 3, all constructs in our model satisfy these two criteria for discriminant validity. Therefore, our measurement model exhibits the sound reliability and validity necessary for further testing of our research hypotheses.

5.4. Structural model assessment and hypothesis testing

The results of hypothesis testing using PLS are summarized in Fig. 3 and Table 4. In Fig. 3, R² values, which reflect the amount of variance explained by the model or the predictive power of the model, are presented within the oval of each endogenous variable. The model explains 12.7% of the variance in structural assurance, 22.4% in perceived risk, 26.6% in performance expectancy and 50.9% of the variance in behavioral intention.

We also performed bootstrapping to compute the t-statistics for each hypothesized relationship and the potential impact of covariates. None of the covariates were significant. The hypothesized relationships were significant except for H3, H6, H8, and H9. Against expectations, pre-existing trust belief in the bank was found to have no significant impact on perceived risk in mobile banking, performance expectancy, and behavioral intention to adopt mobile banking services. Self-efficacy also fails to have a significant impact on the perceived risk in mobile banking.

6. Discussion and post-hoc analysis

One general research question drove this study: How do multi-dimensional trust and multi-faceted risk perception at the individual level influence the acceptance of emerging innovative technologies? In an effort to answer this question, this study provides a theoretical framework to investigate the salient antecedents of MB services acceptance. Our research further advances the literature of initial adoption/acceptance of innovative technologies, particularly in the arena of mobile banking (e.g.: [41,42,52]).

6.1. Summary of findings

The main objective was to identify the integral role of trust versus risk and the impact of multi-dimensional trust, multi-faceted risk perception, self-efficacy, and performance expectancy on adoption of an emerging IT artifact. An empirical study was conducted to test the theoretical model. The results indicate that performance expectancy is the most significant determining factor for MB services acceptance, with a standardized coefficient of 0.499 (H4). This finding implies that performance expectancy as perceived by users is still the core determinant of acceptance and lends further support to prior technology acceptance studies that came to similar conclusions [27,28,83,90]. In addition to confirming the appropriateness of employing this construct in new IT phenomena, this study also reveals that risk perception derived from multiple facets is a salient antecedent to innovative technology acceptance. The second-order

Table 2
Loadings, composite reliability (CR) and average variance extracted (AVE) of measurement instruments.

Constructs/items	Loadings														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1. SE	SE1	0.80***	0.23	0.17	0.29	-0.07	-0.13	-0.09	-0.02	0.04	-0.18	-0.10	-0.07	0.23	0.31
CR = 0.85	SE2	0.81***	0.19	0.15	0.24	-0.11	-0.21	-0.10	-0.13	0.02	-0.27	0.03	-0.14	0.18	0.24
AVE = 0.66	SE3	0.82***	0.07	0.12	0.14	-0.05	-0.08	-0.05	-0.10	-0.02	-0.17	-0.04	-0.17	0.27	0.28
2. TD	TD1	0.16	0.81***	0.30	0.18	-0.17	-0.18	-0.11	0.03	0.06	-0.24	0.15	-0.26	0.14	0.37
CR = 0.92	TD2	0.12	0.86***	0.26	0.14	-0.13	-0.09	-0.08	0.02	0.17	-0.06	0.34	-0.19	0.23	0.38
AVE = 0.73	TD3	0.20	0.84***	0.34	0.15	-0.21	-0.24	-0.16	-0.18	-0.03	-0.13	0.27	-0.31	0.22	0.34
	TD4	0.19	0.91***	0.42	0.24	-0.23	-0.24	-0.22	-0.06	0.12	-0.19	0.15	-0.38	0.29	0.44
3. PE	PE1	0.13	0.42	0.83***	0.25	-0.40	-0.34	-0.22	-0.20	-0.06	-0.34	0.04	-0.44	0.29	0.66
CR = 0.89	PE2	0.14	0.15	0.57***	0.08	-0.17	-0.03	-0.04	-0.02	-0.13	-0.27	-0.04	-0.11	0.10	0.19
AVE = 0.63	PE3	0.13	0.24	0.84***	0.27	-0.47	-0.33	-0.38	-0.26	-0.19	-0.43	-0.05	-0.37	0.27	0.52
	PE4	0.25	0.26	0.86***	0.26	-0.43	-0.26	-0.26	-0.22	-0.05	-0.35	0.03	-0.34	0.34	0.51
	PE5	0.09	0.41	0.83***	0.27	-0.36	-0.23	-0.29	-0.04	0.13	-0.19	0.07	-0.32	0.37	0.57
4. TRUST	TRUST1	0.26	0.14	0.27	0.82***	-0.18	-0.25	-0.08	-0.13	-0.14	-0.25	-0.04	-0.24	0.30	0.25
CR = 0.84	TRUST2	0.29	0.20	0.22	0.77***	-0.15	-0.24	-0.17	0.02	-0.06	-0.11	-0.14	-0.17	0.36	0.28
AVE = 0.51	TRUST3	0.13	0.23	0.24	0.66***	-0.24	-0.29	-0.27	0.07	0.15	-0.12	-0.09	-0.21	0.39	0.29
	TRUST4	0.08	0.19	0.18	0.61***	-0.27	-0.21	-0.04	0.04	0.15	-0.10	0.02	-0.18	0.31	0.19
	TRUST5	0.18	-0.06	0.12	0.69***	-0.25	-0.24	-0.17	-0.27	-0.12	-0.17	-0.10	-0.11	0.25	0.14
5. FINANC	FRISK1	-0.13	-0.18	-0.35	-0.29	0.66***	0.40	0.24	0.31	0.11	0.37	0.01	0.41	-0.30	-0.26
CR = 0.85	FRISK2	-0.01	-0.19	-0.37	-0.24	0.78***	0.43	0.45	0.17	0.10	0.39	0.01	0.55	-0.27	-0.30
AVE = 0.59	FRISK3	-0.19	-0.17	-0.40	-0.23	0.78***	0.51	0.41	0.31	0.09	0.37	-0.08	0.42	-0.37	-0.38
	FRISK4	0.03	-0.15	-0.37	-0.18	0.84***	0.54	0.47	0.26	-0.01	0.43	-0.10	0.51	-0.33	-0.35
6. PERFOR	PFRISK1	-0.04	0.00	-0.30	-0.28	0.57	0.63***	0.39	0.14	0.13	0.31	0.04	0.26	-0.28	-0.30
CR = 0.80	PFRISK2	-0.05	-0.27	-0.30	-0.27	0.50	0.82***	0.40	0.25	0.18	0.40	0.05	0.52	-0.35	-0.34
AV = 0.50	PFRISK3	-0.22	-0.18	-0.14	-0.16	0.23	0.55***	0.46	-0.02	-0.08	0.23	0.05	0.34	-0.30	-0.29
	PFRISK5	-0.20	-0.16	-0.19	-0.27	0.41	0.80***	0.45	0.29	0.11	0.40	0.09	0.48	-0.24	-0.33
7. PRIVACY	PRRISK1	-0.21	-0.13	-0.26	-0.23	0.36	0.56	0.82***	0.20	0.16	0.28	0.21	0.54	-0.33	-0.36
CR = 0.78	PRRISK2	-0.07	-0.25	-0.33	-0.18	0.42	0.35	0.77***	0.10	0.12	0.37	0.03	0.46	-0.30	-0.36
AVE = 0.55	PRRISK2	0.11	0.02	-0.10	-0.02	0.37	0.38	0.62***	0.06	0.01	0.21	0.16	0.35	-0.21	0.00
8. PSY	PSYRISK1	-0.06	-0.02	-0.13	0.12	0.34	0.19	0.15	0.82***	0.36	0.34	-0.05	0.27	-0.05	-0.14
CR = 0.78	PSYRISK2	-0.10	-0.08	-0.21	-0.23	0.20	0.23	0.12	0.78***	0.52	0.29	0.11	0.26	0.03	-0.16
AVE = 0.64															
9. SOCIAL	SORISK1	0.10	0.11	-0.12	0.01	0.16	0.13	0.12	0.52	0.91***	0.31	0.08	0.13	0.22	0.02
CR = 0.87	SORISK2	-0.11	0.06	0.03	-0.02	-0.03	0.11	0.12	0.43	0.84***	0.24	0.24	0.14	0.15	-0.04
AVE = 0.77															
10. TIME	TIRISK1	-0.18	-0.15	-0.30	-0.19	0.33	0.31	0.22	0.26	0.20	0.67***	0.04	0.41	-0.09	-0.40
CR = 0.85	TIRISK2	-0.28	-0.09	-0.31	-0.13	0.42	0.44	0.32	0.30	0.17	0.75***	0.03	0.42	-0.21	-0.23
AVE = 0.60	TIRISK3	-0.07	-0.16	-0.33	-0.15	0.45	0.35	0.38	0.32	0.32	0.81***	0.06	0.47	-0.24	-0.27
	TIRISK4	-0.26	-0.13	-0.27	-0.19	0.37	0.39	0.29	0.33	0.29	0.84***	0.10	0.49	-0.11	-0.23
11. PHYSIC	PHYRISK1	-0.08	0.36	-0.05	-0.07	-0.04	0.02	0.15	0.10	0.27	0.12	0.86***	0.12	-0.03	0.08
CR = 0.92	PHYRISK2	0.04	0.39	0.08	0.02	-0.12	-0.08	0.10	0.08	0.34	0.00	0.66***	0.00	0.09	0.23
AVE = 0.69	PHYRISK3	0.02	0.31	0.10	0.00	-0.14	0.01	0.03	0.14	0.25	0.04	0.82***	0.12	0.08	0.15
	PHYRISK4	-0.10	0.07	-0.03	-0.14	0.03	0.11	0.18	-0.05	-0.02	0.02	0.84***	0.16	-0.12	-0.11
	PHYRISK5	0.02	0.19	0.07	-0.11	-0.06	0.11	0.20	-0.04	0.11	0.07	0.89***	0.18	-0.06	0.12
12. OVERAL	ORISK1	-0.24	-0.37	-0.42	-0.28	0.53	0.47	0.48	0.29	0.12	0.56	-0.05	0.77***	-0.38	-0.47
CR = 0.88	ORISK2	-0.10	-0.20	-0.20	-0.09	0.41	0.44	0.51	0.14	0.08	0.35	0.23	0.80***	-0.20	-0.28
AVE = 0.59	ORISK3	-0.07	-0.20	-0.29	-0.16	0.40	0.42	0.41	0.39	0.29	0.49	0.24	0.80***	-0.18	-0.32
	ORISK4	0.04	-0.13	-0.34	-0.11	0.46	0.34	0.45	0.33	0.16	0.39	0.26	0.72***	-0.22	-0.37
	ORISK5	-0.23	-0.37	-0.37	-0.34	0.54	0.53	0.51	0.12	-0.08	0.44	0.00	0.73***	-0.51	-0.46
13. SA	SA1	0.32	0.27	0.33	0.47	-0.34	-0.38	-0.31	-0.01	0.19	-0.22	-0.07	-0.40	0.91***	0.38
CR = 0.92	SA2	0.27	0.28	0.25	0.47	-0.34	-0.42	-0.32	-0.02	0.19	-0.18	-0.10	-0.40	0.88***	0.37
AVE = 0.73	SA3	0.20	0.18	0.37	0.30	-0.36	-0.27	-0.34	-0.01	0.16	-0.21	0.02	-0.29	0.85***	0.29
	SA4	0.13	0.16	0.33	0.28	-0.40	-0.31	-0.39	-0.01	0.22	-0.10	0.01	-0.22	0.79***	0.28
14. BI	BI1	0.39	0.45	0.61	0.35	-0.41	-0.39	-0.32	-0.12	0.06	-0.30	0.11	-0.45	0.39	0.91***
CR = 0.93	BI2	0.28	0.48	0.56	0.29	-0.41	-0.45	-0.36	-0.07	0.11	-0.30	0.12	-0.49	0.40	0.90***
AVE = 0.77	BI3	0.28	0.42	0.54	0.27	-0.28	-0.39	-0.25	-0.22	0.00	-0.26	0.03	-0.43	0.28	0.90***
	BI4	0.24	0.23	0.59	0.26	-0.39	-0.32	-0.30	-0.27	-0.20	-0.38	-0.04	-0.38	0.30	0.79***

Note: SE – Self-Efficacy; TD – Disposition to Trust; PE – Performance Expectancy; TRUST – Trust Belief; FINANC – Financial Risk; PERFOR – Performance Risk; PRIVACY – Privacy Risk; PSY – Psychological Risk; SOCIAL – Social Risk; TIME – Time Risk; PHYSIC – Physical Risk; OVERAL – Overall Risk; SA – Structural Assurance; BI – Behavioral Intention; ***p<0.001.

analysis indicates that perceived risk has six significant facets: financial, performance, privacy, time, psychological, and overall risks. Two facets, social and physical risks, are insignificant. The physical risks of cell phones that have been reported recently in the news media clearly have not achieved a sufficient awareness level among consumers. In terms of the significant standardized coefficient, perceived risk is -0.442 (H5). What this finding suggests is that risk perception stemming from these important facets can significantly reduce potential users' behavioral intention to adopt MB services. Therefore, these results may imply that those who believe MB services

are useful and perceive lower potential risks of financial transactions in the wireless platform will tend to embrace this innovative technology early.

Our research model distinguishes three types of trust: trust disposition, initial trust perception of wireless Internet platform (structural assurance) and pre-existing trust of banks (trust belief). Structural assurance significantly influences behavioral intention through adjusting people's risk perceptions. However, our results do not support the direct influence of trust belief (pre-existing trust toward banks) on behavioral intention. The pre-existing trust toward

Table 3
Discriminant validity of measurement model; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Construct	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. SE	0.81													
2. TD	0.20*	0.86												
3. PE	0.18*	0.39***	0.79											
4. TRUST	0.27**	0.21*	0.30***	0.71										
5. FINANC	-0.09	-0.22*	-0.48***	-0.30***	0.77									
6. PERFOR	-0.17	-0.22*	-0.33***	-0.35***	0.62***	0.71								
7. PRIVACY	-0.10	-0.18	-0.33***	-0.21*	0.52***	0.59***	0.74							
8. PSY	-0.10	-0.06	-0.21*	-0.06	0.34***	0.26**	0.17	0.80						
9. SOCIAL	0.01	0.10	-0.06	0.00	0.09	0.14	0.14	0.55***	0.88					
10. TIME	-0.25**	-0.17	-0.39***	-0.22*	0.51***	0.48***	0.39***	0.39***	0.32***	0.77				
11. PHYSIC	-0.04	0.26**	0.02	-0.10	-0.05	0.08	0.18	0.03	0.17	0.07	0.83			
12. OVERAL	-0.16	-0.34***	-0.43***	-0.26**	0.62***	0.58***	0.62***	0.33***	0.15	0.59***	0.17	0.76		
13. SA	0.28**	0.27**	0.37***	0.46***	-0.42***	-0.41***	-0.39***	-0.02	0.22*	-0.21*	-0.05	-0.39***	0.86	
14. BI	0.34***	0.45***	0.66***	0.34***	-0.42***	-0.44***	-0.35***	-0.19*	-0.01	-0.36***	0.07	-0.50***	0.39***	0.88

banks fails to carry over or extend to facilitating the adoption of MB services. This finding differs from prior e-commerce studies in which trust belief plays a direct role in technology adoption/acceptance [5,25,27,28,54]. The insignificant role of pre-existing trust toward banks may be attributed to two reasons. First, MB uses open air as transmission media that falls partly *outside the control* of banks. Potential customers of MB service may perceive higher risks in wireless Internet platform. Another reason may be highly sensitive nature of financial information of MB service, which could further prevent pre-existing trust from overcoming the inherent risks or uncertainties in embryonic mobile banking.

Furthermore, we conjecture that this intriguing finding increases the chance for gauging the potential for personal factors, such as disposition to trust and self-efficacy, to exert direct influence over the behavioral intention to adopt new technologies. As such, a post-hoc analysis was conducted in order to seek the additional path analyses between these two personal trait factors and behavioral intention. As shown in Fig. 4, both personal trait factors do directly affect behavioral intention toward MB services acceptance, with standardized coefficients of 0.177 and 0.167, respectively. Accordingly, the endogenous variable's R^2 value, which reflects the predictive power of the model, increased to 55.9%. Thus we may conclude that users who have a higher tendency to trust others and greater self-efficacy will participate in the early adoption of MB services.

6.2. Implications for research

The results of the study described above have several important implications for research on decision support for the adoption of *embryonic IT-enabled* products or services such as mobile banking. First, the adoption intention is primarily driven by the joint assessment of the utility of the products or services and the risks arising from the products or services and underlying IT platform. Such joint assessment constitutes a cost-benefit calculus. Studies that focus only on costs or benefits will yield incomplete or contradictory findings.

Second, the results of this study also suggest the necessity of considering the adoption stage of IT-enabled products or services. In the early adoption stage of an IT-enabled artifact such as mobile banking, consumers are uncertain not only about the products or services but also about the soundness of the underlying technology platform. Consequently, this dual uncertainty escalates the importance of studying what constitutes the major dimensions of the risks perceived by consumers and what mechanisms are effective in helping consumers overcome their uncertainties about the products or services and underlying technical platform. For example, we found that personal trait factors such as trust disposition and self-efficacy become the major levers to override the effect of perceived risks and directly influence the intention to adopt mobile banking. As the products or services mature, consumers will acquire more concrete

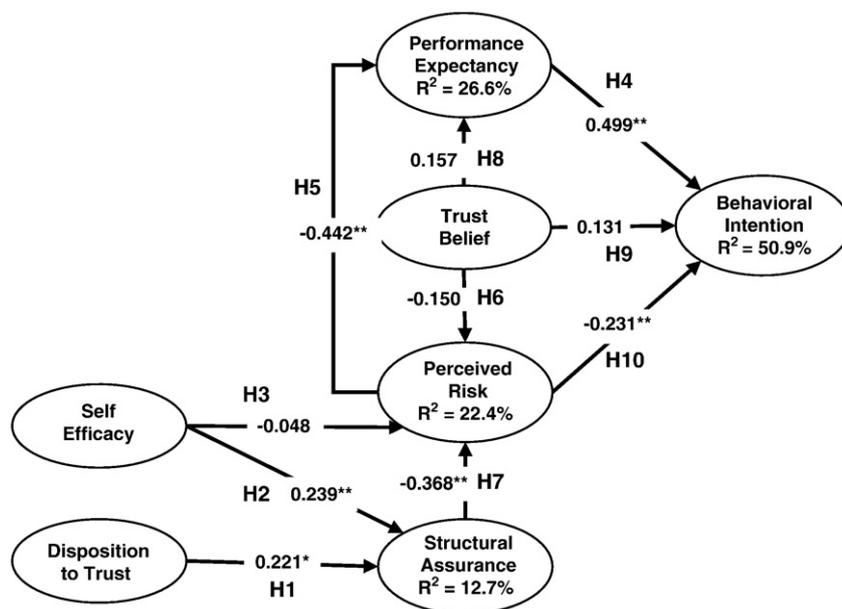


Fig. 3. Results of testing hypotheses using PLS analysis. Completely standardized estimates, controlled for covariates in the research model, * $p < 0.05$, ** $p < 0.01$.

Table 4
Summary of hypothesis testing results.

Hypotheses	Path coefficients	t Value	p Value
H1: Disposition to trust has a positive impact on structural assurance.	0.221	2.51	$p < 0.05$ (supported)
H2: Self-efficacy is positively associated with structural assurance.	0.239	2.92	$p < 0.01$ (supported)
H3: Self-efficacy is negatively associated with perceived risk.	-0.048	0.474	$p > 0.05$ (not supported)
H4: Performance expectancy is positively associated with behavioral intention to adopt wireless banking.	0.499	6.78	$p < 0.01$ (supported)
H5: Perceived risk is negatively associated with performance expectancy.	-0.442	4.92	$p < 0.01$ (supported)
H6: Trust beliefs toward a bank will have a negative effect on perceived risks in mobile banking.	-0.150	1.55	$p > 0.05$ (not supported)
H7: Structural assurance has a negative impact on perceived risk.	-0.368	3.58	$p < 0.01$ (supported)
H8: Trust belief has a positive impact on performance expectancy.	0.157	1.36	$p > 0.05$ (not supported)
H9: Trust beliefs toward a bank will have a positive effect on consumers' behavioral intention to adopt mobile banking.	0.131	1.47	$p > 0.05$ (not supported)
H10: Perceived risks toward mobile banking will have a negative effect on consumers' behavioral intention to adopt mobile banking.	-0.231	3.09	$p < 0.01$ (supported)

knowledge about them and about the soundness of the underlying technology platform and will form more specific trust or risk beliefs. In this case, the effect of personal trait factors is expected to be fully mediated through specific beliefs.

Third, different dimensions of trust play different roles in the adoption of embryonic IT-enabled artifacts. Structural assurance or trust toward the technology platform acts as an important mechanism to overcome the perceived risks of mobile banking and indirectly affects adoption intention, while trust disposition directly affects adoption intention. Future studies should separate these different dimensions of trust and consider the adoption stage of IT artifacts when speculating about the effect of these trust dimensions.

Fourth, pre-existing trust belief toward a vendor may not be extensible to the adoption of a new product or service offered by that vendor, especially for embryonic IT-enabled artifacts involving new risks in both the product or service and the underlying technology. Further studies are needed to identify factors constraining the effect of pre-existing trust toward a vendor.

6.3. Implications for practice

This study also has several important practical implications for decision-makers in banks offering MB service. First, the relative magnitude of the path coefficients in our analysis model suggests that performance expectancy, or the expected utility of mobile banking, is

the most important factor that directly enhances the adoption intention. Banks could effectively increase the adoption intention through disseminating the benefits of MB to potential consumers.

Second, given the initial adoption stage of MB services, users may have relatively vague knowledge about the soundness of the wireless Internet as a platform through which financial transactions can be made. The significant impact of structural assurance found in this study suggests that an effective strategy to help consumers overcome their risk perceptions of MB is to educate them about the wireless Internet platform and increase their awareness of the security of the technologies implemented. Future studies should investigate how to influence consumers' knowledge about mobile banking and the wireless Internet platform.

Third, by modeling perceived risk as a formative construct with eight facets, this research pinpoints several risk considerations, including financial risk, performance risk, privacy risk, time risk, and psychological risk, that may delay the adoption of MB services in the initial stage. When banks promote their MB services to facilitate the adoption among potential customers, they should pragmatically emphasize countermeasures for those risk perceptions. For example, MB service providers may advertise a financial loss protection policy and the underlying technological support for anti-fraud protection to assure potential consumers about the minimal financial risks; they may provide customers with a satisfaction guarantee to reduce performance risk and offer secondary transaction channels and a user-

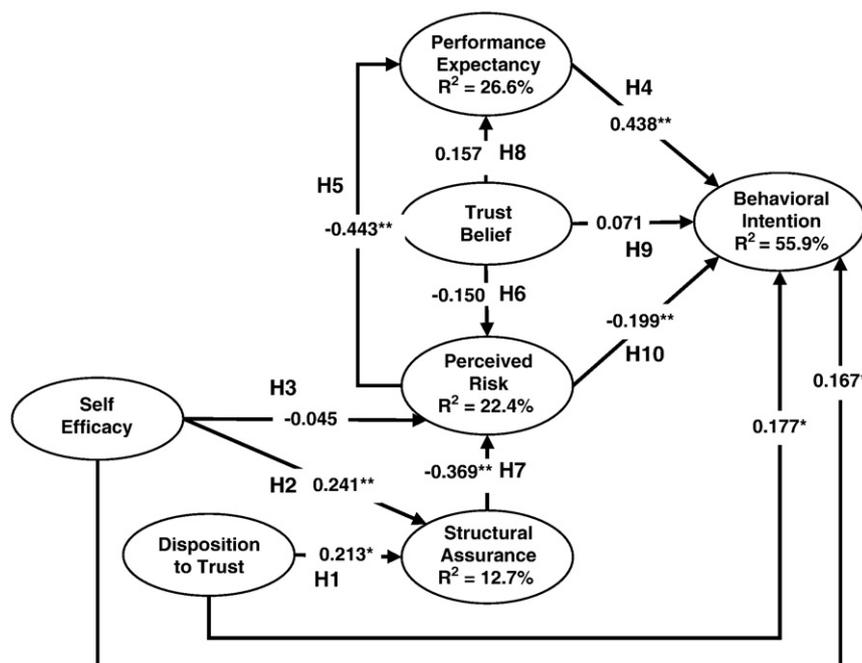


Fig. 4. Post-hoc analysis results of testing hypotheses using PLS analysis. Completely standardized estimates, controlled for covariates in the research model, * $p < 0.05$, ** $p < 0.01$.

friendly transaction interface to mitigate time risk. To alleviate self-image risk (or psychological risk), banks may offer incentives for potential customers to try their MB services. In addition, risks of the MB service perceived by potential customers may not well reflect the actual level of risks. Some of the significant risk dimensions found in this study such as time risk and financial risk could be actually lower than the traditional banking service. For example, one of the biggest advantages of MB is convenience, being able to conduct financial transactions from anywhere and saving the time spent in traveling or even waiting in lines. MB could also help customers detect fraudulent financial transactions earlier through accessing their account information at anytime and anywhere. Therefore, banks should emphasize potential advantages of MB services to directly address some of the exaggerated risks perceived by potential customers. Another path to alleviate perceived risk is through structural assurance. The results of our study show that structural assurance is an important antecedent of perceived risk, suggesting that doubt about the mobile communication channel is still a barrier to the acceptance of MB services. Legal and technical assurance and customer awareness of such assurance are useful for decreasing perceived risk and therefore will further promote and facilitate the acceptance of MB services.

Lastly, self-efficacy is found to be particularly important for the adoption of *embryonic IT-enabled* products or services such as mobile banking. Banks should partner with wireless service providers to help potential customers of MB service to increase their perceived capability to perform MB banking. For example, they should provide step-by-step guidance in text and/or demo videos about MB service. Also, they should jointly launch free trial MB service or use other promotions to encourage potential MB customers to get some hands-on experience in MB service.

7. Limitations and future research

All research inevitably confronts limitations. First, the study investigated existing bank customers who are college students majoring in business. Despite prior research that has supported students as good surrogates to mirror typical consumers [79], there might be a threat to the external validity of the study because these students may not fully represent the whole population of all potential MB service users. Future research using non-student subjects is encouraged for greater external validity.

Second, given the innovative nature of MB services and the infancy stage of MB implementation, this study merely focused on behavioral intention as the dependent variable to interpret the theory-driven actual behavior in the early adoption stage. Thus, measurement reliability needs to be further improved in future research, which is hoped to employ additional methods, such as a field study and/or longitudinal analysis, to more closely observe and investigate the differences between adopters and non-adopters in the later stages of MB implementation.

Third, measures of all constructs in this study were collected at the same point in time and via the same self-reported instrument. According to Straub et al. [84], the potential for common methods variance may exist. Therefore, future research using a richer research methodology combining quantitative and qualitative methods is called for. This multi-methodological triangulation method is necessary for researchers to extract potential variables that will help explain improved variances of the dependent variable.

The empirical evidence was collected from subjects living in United States of America which, in terms of national characteristics, is different from other mobile technology advancing nations such as South Korea, Japan, China, and Finland. Thus, we suspect that cultural factors might also affect the adoption/acceptance of MB services across nations. As Srite and Karahanna pointed out [82], we hope that future research can use the espoused national cultural values as moderators to more thoroughly explain the issues of acceptance/

adoption in different cultures which are rooted in different philosophical perspectives and understandings at the individual level.

Focusing on multi-dimensional trust and risk factors, this research intended to provide a comprehensive yet parsimonious decision-making model for MB adoption. While the current model explains 55.9% of the variance in behavioral intention, in future research we hope to further improve the explanatory power by including additional constructs, e.g., effort expectancy or perceived ease-of-use.

8. Conclusion

The objective of this study was to formulate and test empirically a model of how multi-dimensional trust and multi-faceted risk perception, at the individual level, may influence the acceptance of emerging IT artifacts in terms of mobile banking services. This paper's goal was to clarify the difference between Internet banking and mobile banking, in addition to identifying two distinguishing features of mobile banking: use of a wireless Internet platform and its initial adoption stage.

Our research model successfully incorporates these two distinguishing features to investigate the major factors, such as trust (i.e., pre-existing trust, structural assurance, and trust disposition), risk (i.e., eight facets), self-efficacy, and performance expectancy, thus driving the early adoption of mobile banking services. The results support the proposed model and also highlight the potential influence and appropriateness of employing personal trait factors in analyzing emerging IT artifacts' acceptance. The authors hope that this research model stimulates further research and provides a useful lens for conjointly examining *comprehensive* risk perception and trust in the context of acceptance of emerging innovative technology in its early adoption stage.

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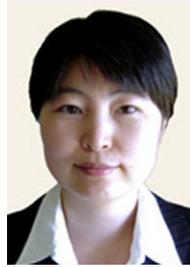


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