Electronic Commerce Research and Applications xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Electronic Commerce Research and Applications

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

M-S-QUAL: Mobile service quality measurement

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ARTICLE INFO

Article history:
Received 12 September 2013
Received in revised form 10 January 2015
Accepted 11 January 2015
Available online xxxx

Keywords:
Mobile commerce
Mobile service
Service quality
Instrument development

ABSTRACT

The proliferation of wireless technologies means that consumers are increasingly coming into contact with a diverse range of mobile services. Mobile service providers seeking to deliver a superior service must understand how consumers perceive these services. Although many instruments, such as SERVQUAL and E-S-QUAL, are available to measure service quality in general, to date there has been no instrument specifically designed to measure mobile service quality. Given the many types of mobile services available, our aim in this study was to ascertain the essential characteristics of such services by conceptualizing, constructing, refining, and testing a multiple-item scale, M-S-QUAL, designed to measure service quality in the mobile environment. According to Hinkin's guidelines on scale development, the items in our scale were generated by following a deductive approach based on a theoretical foundation. There are two parts of M-S-QUAL, which assess m-commerce shopping experiences for virtual and physical products respectively. Thus, the scale developed in this study was designed to assess m-commerce shopping experiences for both virtual and physical products. We propose and empirical test a multidimensional model of M-S-QUAL using a sample of 578 Internet respondents. Through a five-step validation, the M-S-QUAL construction concluded with five factors (*contact*, *responsiveness*, *fulfillment*, *privacy* and *efficiency*) for the supporting services in the process of virtual product shopping and four factors (*contact*, *responsiveness*, *fulfillment* and *efficiency*) for the supporting services in the process of physical product shopping. These two aspects of M-S-QUAL demonstrate good psychometric properties, as confirmed by exploratory factor analysis, confirmatory factor analysis, and reliability and validity tests. The findings of this study will help mobile service providers to assess the quality of their services and assist researchers in developing mobile service quality theories.

1. Introduction

With the development of such handheld devices as personal digital assistants (PDAs), tablets, and smart phones, wireless and mobile technologies and their associated applications have become essential for daily life. According to the International Telecommunication Union (ITU), there were 7 billion mobile subscribers in 2014, a number equivalent to 95% of the world's population (ITU 2014). The Statistics Portal (Statista) also predicted that retail m-commerce sales through smartphones in the U.S. will exceed 22 billion dollars in 2015, and in 2017 more than 90% of Internet users will access online content through their handheld devices (Statista 2014). These figures imply a very rapid evolution of Internet access and the mobile market, with ever-increasing numbers of people using handheld devices. These figures imply the very rapid evolution of Internet access and the mobile market, with ever-increasing numbers of people using handheld devices. Advanced and mature mobile communication technologies have facilitated the development of a variety of mobile commerce (m-commerce) applications, including location-based services, mobile reading services, electronic books, mobile TV, and mobile music. The m-commerce market is growing at full speed with the rapid development of m-commerce applications.

Although the m-commerce market looks extremely promising, this market environment was previously unimaginable, and is even now only vaguely understood. Businesses are eager to grasp the potential opportunities in m-commerce, but do not fully understand the new paradigm involved. In any market, however, the first step in serving customers well is to offer excellent service. Service quality is crucial to a firm's long-term success, and providing a

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http://dx.doi.org/10.1016/j.elerap.2015.01.003
1567-4223/

superior service to customers is essential to gaining a competitive advantage (Caro and Garcia 2007). Mobile service providers who seek to deliver a superior service must understand how consumers perceive their mobile services, and such understanding requires a means of measuring service quality. As Peter Drucker is often quoted as saying, "You can't manage what you can't measure" or "If you can't measure it, you can't improve it." The measurement of mobile service quality is essential to mobile service providers and to the development of m-commerce. In this paper, we focus on mobile service that supports users in making purchases anytime and anywhere on mobile platforms, rather than the telecommunication carriers' mobile service as an infrastructure. To date, investigations into the quality of such m-commerce service have been rare. Important research questions concerning mobile service are "What factors constitute mobile service quality, and how do these factors differ from those of traditional off-line markets or web-based e-commerce?" This paper provides answers to this question by systematically constructing a mobile service quality instrument that we call the M-S-QUAL.

In the context of B2B e-commerce, the primary issue is the seamless integration of operations across organizations rather than service quality. The existence of an inter-organizational B2B infrastructure mandates its use by personnel who carry out relevant tasks regardless of service quality. Thus, in this study of m-commerce service quality, a B2C environment is presumed. There are several differences between m-commerce and e-commerce. Clarke and Flaherty (2003) identified four characteristics of m-commerce: ubiquity, convenience, localization, and personalization. The characteristics that are not found in general e-commerce are ubiquity and localization. Although in the past two decades e-commerce has provided great convenience and made personalization feasible at a large scale, m-commerce has brought these two aspects to the next level. With mobile capability, the access to information is ubiquitous. Positioning technology such as the Global Positioning System (GPS) provides localization services for mobile devices (Rao and Minakakis 2003), which has facilitated the development of location-based applications that connect directly to a user's location. Localization and ubiquity implies that there is profound opportunity for businesses to engage consumers anytime and at any place.

Unlike traditional e-commerce in which physical products dominate the market, m-commerce features a proliferating range of virtual products. Physical products are tangible items that can be actually handled and can only be shipped via physical transportation, whereas virtual products are intangible products that exist in digital form and can be conveniently delivered via digital channels. However, not all intangible products are virtual products, as many intangible products cannot be delivered via digital channels and/or are not in digital form. Digital content can also become a physical product if it is recorded and sold in physical form, as in the case of DVDs. Such content is properly called a virtual product if it is organized as a digital file for transmission over digital channels such as the Internet. So far, the quality of service offered by merchants of virtual products has been little studied and is inadequately understood. Consumers may value different aspects of service when virtual products are concerned, but this too is little explored.

Mobile users may have different expectations concerning service quality when they are buying physical products than when they buy virtual products. The disparate natures of virtual and physical products lead to different user perspectives and different modes of marketing. The incremental costs of producing virtual products are much lower than those of producing physical products, and the process of delivering virtual products is much less complicated. Virtual products are delivered through digital channels, which represent a convenient venue characterized by high speed, low cost, low maintenance and low rates of failure. In contrast, the delivery of physical products requires transportation systems that are typically characterized by slow speed, high cost, high maintenance and high rates of failure. In general, it is much easier to maintain quality consistency for virtual products. Therefore, in view of these less challenging processes of manufacturing and delivery, users of virtual products may be less tolerant of product or delivery failures. Currently, most of the virtual products offered through the mobile environment are easy to deliver and low in price, e.g., various apps. Therefore, users may perceive lower monetary risks in making purchases, and they may be satisfied with nominal compensations for failures by the sellers. It will be of great interest to see how the differences in service requirements for virtual and physical products play out in the m-commerce market. Thus, the M-S-QUAL constructed in this study consists of two parts that separately assess m-commerce shopping experiences for virtual and physical products.

It has grown necessary to develop a service quality measure for the mobile commerce market. To date, there has been no integrated scale for assessing the quality of service to shoppers who use mobile devices in buying virtual and physical products. Therefore, there is a need to develop and validate the M-S-QUAL instrument for measuring mobile service quality as perceived by shoppers in the mobile environment. The M-S-QUAL enables mobile service providers to assess the quality of their shopping services and identify areas for improvement. In developing and evaluating this instrument, we made a distinction between the experiences of m-commerce shopping for virtual or for physical products. This distinction further ensures the M-S-QUAL instrument's applicability to both categories of mobile service. This instrument consists of two parts, one for measuring the users' m-commerce experience in buying physical products and the other for measuring satisfaction in buying virtual products. To the best of our knowledge, no prior research has systematically constructed a mobile service quality instrument specific to mobile commerce, or investigated the distinction between shopping for virtual and physical products. This paper, therefore, constitutes a milestone in m-commerce research.

The remainder of the paper is structured as follows. Section 2 provides an introduction to m-commerce, service quality, and mobile service quality. Section 3 describes the research methods, and Section 4 presents the analytical results. Section 5 draws conclusions, discusses the study's implications and limitations, and suggests directions for future research.

2. Literature review

2.1. Mobile commerce

The convergence of mobile telecommunications and the Internet has given birth to many exciting possibilities for and driven the growth of m-commerce. The penetration of daily life by both technologies has engendered changes in how we work, live, learn, and consume. The following sections introduce and discuss various topics in the m-commerce literature.

2.1.1. From e-commerce to m-commerce

The use of wired communication devices to conduct business activities external to firms is traditionally termed e-commerce. Advanced and mature wireless and mobile technologies have been very effective in propelling e-commerce to embrace the potential of m-commerce. M-commerce can be viewed as a subset of e-commerce (Coursaris and Hassanein 2002; Kwon and Sadeh 2004). The term *m-commerce* refers to any shopping activities with a monetary value that is conducted via a mobile device (Clarke

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2001). It typically involves the use of a handheld mobile device and connection via an always-on, high-speed Internet link to engage in communication, interaction, and shopping activities. In m-commerce, mobile communication devices are used to conduct business activities outside enterprises, such as buying a product via a mobile phone that connects to a website. Clarke and Flaherty (2003) identified four characteristics of m-commerce: ubiquity, convenience, localization, and personalization. Companies provide mobile services to consumers on the basis of these characteristics. M-commerce clearly differs from traditional e-commerce in that it has overcome many of the latter's limitations and makes many new applications possible.

2.1.2. Scope of m-commerce applications

M-commerce encompasses an extensive array of applications, and involves a chain of value-added activities that terminates with the consumer. The European Commission (1996) developed a framework to describe these activities based on a concept taken from Porter and Millar's (1985) traditional value chain analysis. The basic framework comprises six core processes in two main areas. One of the main areas is infrastructure and services, and the other is content and product. The former consists of three core processes, mobile presentation, mobile transport, and mobile application; the latter consists of three other core processes, content/product creation, packaging, and delivery. The m-commerce value chain framework shown in Fig. 1 is adapted from the European Commission's (1996) specifications.

Infrastructure and services concern transport technologies, services presenting technologies, and application development. Mobile transport, mobile presentation, and mobile applications are all infrastructure and services. They support user and consumer access to networks and mobile services. Content and products are services that are created, packaged, and delivered, and finally received by consumers. The six core elements in these two areas are the building blocks of the m-commerce value chain, which provides a clear and concise framework for m-commerce and defines its scope.

2.1.3. Products and services in mobile services

From 1G to 3.5G, m-commerce products and services have become increasingly diverse. Nysveen et al. (2005) proposed a mobile service classification framework along two axes: *interactivity* (person interactive versus machine interactive) and *process* (goal-directed process versus experiential process). Person interactivity refers to person-to-person interaction via a medium; machine interactivity refers to person-to-medium interaction, where the content presented by a machine to a person is customized to the scenario of interaction in the mediated environment. A goal-directed process is characterized by utilitarian benefits, whereas an experiential process is characterized by hedonic benefits. Using this framework, mobile services can be classified into four types mapped to the four quadrants of the framework: contact, payment, gaming, and messaging, as shown in Fig. 2. Clearly, contact, payment, gaming, and messaging are virtual products. Physical products do not seem to be adequately considered in the framework. Although physical products are not as common as virtual products in the mobile service context at present, they are being offered via mobile services. Accordingly, we incorporated both virtual and physical products in our instrument.

2.2. Service quality

Many studies have examined service quality, but the most influential is that of Parasuraman et al. (1988), who developed the SERVQUAL instrument of service quality. Their instrument may not have demonstrated the desirable reliability and validity, as pointed out by Buttle (1996). To elaborate eleven points of criticisms of SERVQUAL as summarized by Buttle is not possible, but the most easily comprehended point is that "the over(all) SERVQUAL score accounts for a disappointing proportion of item variances" (p. 11; Buttle 1996). Nevertheless, most service quality research is based on the concept and original framework proposed in Parasuraman et al. (1988). In light of technological developments and the shifting of the service delivery channel from offline to online, the same group of authors later developed an electronic service quality measurement scale (E-S-QUAL) to measure the service quality of e-commerce websites (Parasuraman et al. 2005). We review the service quality concept in the following section.

2.2.1. Conceptualization of service quality

Consumers find it more difficult to evaluate the quality of a virtual product than the quality of a physical good, as the former is intangible in nature. Hence, price often becomes a pivotal quality indicator in the absence of information. Service quality can be perceived as the gap between consumer expectations and actual service performance. The user's perception of service quality is formed not only during the purchasing process (which ends when payment is made), but also during the product delivery process. In case of delivery failure, the recovery process also contributes to the perception of service quality. Parasuraman et al. (1985) conducted an exploratory study investigating the concept of service quality in which they suggested that gaps exist between consumers and marketers and that if marketers wish to satisfy consumers, then they must strive to bridge those gaps.

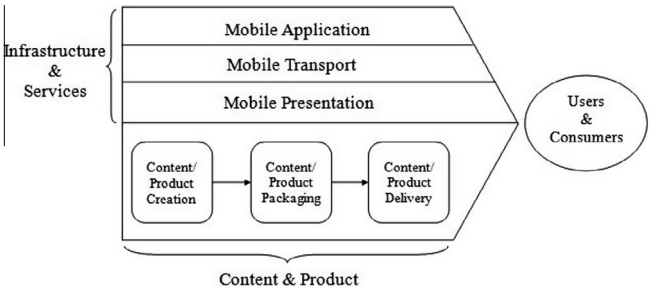

Fig. 1. The m-commerce value chain.

Fig. 2. Mobile service classification framework.

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The aforementioned SERVQUAL model developed by Parasuraman et al. (1988) identified 10 determinants of perceived service quality: *reliability*, *responsiveness*, *competence*, *access*, *courtesy*, *communication*, *credibility*, *security*, *understanding/knowing consumers*, and *tangibles*. The same research group subsequently developed a 22-item instrument to measure service quality pertaining to five factors summarized as Table 1 and Appendix A and the contents in this appendix are taken from Table A-1; namely, *tangibles, reliability, responsiveness, assurance,* and *empathy,* and their perceptions of the service quality they received (Parasuraman et al. 1991). The scale was used to measure customers' expectation of service quality, their perception of service quality received, and the importance of each factor as assessed by customers (Parasuraman et al. 1991).

2.2.2. Electronic service quality

The original SERVQUAL instrument measures offline people-delivered services. As noted, Parasuraman et al. (2005) later developed a multiple-item e-service quality scale, E-S-QUAL, to measure the service quality delivered by websites. Unlike traditional e-commerce service quality assessments, E-S-QUAL defines the degree to which a website allows for effective and efficient shopping and product or service delivery; it is an important instrument with an extensive scope. It takes into consideration not only the factors of traditional offline service quality, but also the technical aspects of service quality, such as ease of use, speed of browsing, and privacy and security issues, among others. A more appropriate measure of electronic service quality than the general SERVQUAL, the basic E-S-QUAL scale comprises 22 items in four factors: *efficiency*, *fulfillment*, *system availability*, and *privacy* (Parasuraman et al. 2005). They are summarized in Appendix A. The content in this appendix is taken from Table A-2. *Efficiency* measures the speed and ease with which the website is accessed and used. *Fulfillment* assesses the extent to which the service provider deals with problems concerning order delivery and item availability. *System availability* measures the website's technical functions, and *privacy* gauges the degree to which the site protects consumer information. In developing E-S-QUAL, the researchers considered an eligible respondent anyone with online shopping experience.

In the process of assessing the four factors of E-S-QUAL, the authors recognized the need to measure the service recovery aspect separately because a relatively small number of online shoppers had experience with it. Accordingly, they also developed an e-recovery service quality scale (E-RecS-QUAL) consisting of 11 items in three factors summarized as Appendix A and Table A-3: *responsiveness*, *compensation*, and *contact* (Parasuraman et al. 2005). The items forming these three factors concern non-routine online shopping processes, as not everyone has experienced online shopping problems. *Responsiveness* assesses the effectiveness with which problems and returns are handled; *compensation* measures the extent to which the website compensates consumers for problems; and *contact* addresses whether the website facilitates consumer assistance through various channels, such as by telephone or via online representatives.

Table 1
Summary of SERVQUAL dimensions.

Dimensions	Definition	Items in scale
Reliability	The ability to perform the promised service dependably and accurately	5
Assurance	Employees' knowledge and courtesy and their ability to inspire trust and confidence	4
Tangibles	Physical facilities, equipment, and the appearance of personnel	4
Empathy	The individualized attention the firm provides to its consumers	5
Responsiveness	Willingness to help consumers and provide a prompt service	4

2.2.3. Mobile service quality

Although m-commerce is frequently characterized as an extension of e-commerce, it can also be regarded as a separate channel that delivers unique value to consumers (Balasubramanian et al. 2002). The characteristics of the mobile channel differ markedly from those of other existing channels, thus warranting the development of an independent service quality scale for m-commerce. Such a scale is necessary because mobile technology creates a platform which shapes a new service delivery mode unfamiliar to businesses. For example, E-S-QUAL considers not only the services that firms deliver, but also the technology's effect on service quality. Mobile technology constitutes a major revolution in what we expect of a commerce platform. Thus, the construction of a scale suitable for measuring m-commerce service quality is of vital importance. On the basis of the scale development guidelines laid out by Hinkin (1998), we reviewed the literature pertaining to mobile services to develop the items for our scale.

In m-commerce studies, researchers often encounter the need to measure mobile service quality. For example, Santouridis and Trivellas (2010) identified service quality and consumer satisfaction as the crucial factors leading to consumer loyalty in the mobile telephone sector. They also examined the mediating effect of consumer satisfaction on the relationship between service quality and consumer loyalty. Wang and Liao (2007) conceptualized and measured m-commerce consumer satisfaction using four sub-constructs: content quality, appearance, service quality, and ease of use. Kuo et al. (2009) developed an instrument to evaluate the quality of value-added mobile services, and further investigated the relationships among service quality, perceived value, consumer satisfaction, and post-purchase intention. Their service quality construct was initially grounded in four factors, namely, *content quality*, *navigation and visual design*, *management and consumer service*, and *system reliability and connection quality*, and was measured by 24 items adapted from Chae et al. (2002). In all of these studies, mobile service quality measurement was carried out in response to the need to gain a better understanding of other variables in the context in question. Consequently, each study defined mobile service quality differently and viewed it from a relatively narrow angle.

A number of studies have focused explicitly on finding the factors of mobile service quality. On the basis of the fuzzy system concept, for example, Choi et al. (2007) extracted six factors concerning mobile service quality: *network coverage*, *mobile device*, *value-added services*, *billing system*, *convenience*, and *price structure*. Lu et al. (2009) used mobile brokerage services as an example, and proposed an instrument for mobile service quality measurement. These researchers identified three mobile service quality factors that customers perceive when making use of such brokerage services: *interaction quality*, *environment quality*, and *outcome quality*. *Interaction quality* refers to the quality of service delivery when the customer contacts the m-service provider; *environment quality* reflects how effectively the service provider transmits its service to the customer; and *outcome quality* concerns the customer's usage experience. Again, although these studies focus on devising a mobile service quality measure, the specifics of their context and methodology limit their generalizability to the measurement of mobile services as a whole.

Although the aforementioned measurements are in general agreement about the necessity of incorporating a technical factor, the content of other aspects varies. For example, the aspect of billing is not consistently present. Wang and Liao (2007) and Kumar and Lim (2008) measure the perception of quality in terms of price

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and billing by how economical the service is and whether it provides a convenient payment procedure. Santouridis and Trivellas (2010) include a similar measure. We thus adopted these two items to measure the price and billing factor in our study. The factors related to mobile service quality are shown in Table 2. Any factors unrelated to service quality in the mobile context, such as the service provider's corporate image or technical network quality, were omitted.

3. Research method

Questionnaire surveys are an effective and commonly used research method, and a scale instrument can facilitate their conceptualization and operationalization (Chae et al. 2002). The purpose of this study was to develop a scale for measuring mobile service quality, a key factor in conceptualizing and understanding m-commerce phenomena. The development of this scale was based on the framework proposed by Hinkin (1998), which provides a comprehensive overview of the main steps in scale development for survey research. All the questions in the scale are closed-ended questions, and the principles of exhaustion and mutual exclusion were carefully followed. The procedure is described briefly in the following and summarized in Table 3.

(1) *Item generation:* There are two approaches to generating items: deductive and inductive. When there is an adequate theoretical foundation to generate the initial set of items, a deductive approach is preferable, whereas inductive scale development is appropriate when the meaning of a construct cannot easily be identified and there is no adequate theory with which to generate the items. A number of guidelines should be followed in drafting items. For example, statements should be simple and as brief as possible, and the language used should be familiar to the target respondents. All items in the same construct should be consistent, and those that assess behavior should not be mixed with those that assess affective responses. Content validity should also be assessed in this step.

(2) *Questionnaire administration:* The items that survive content analysis should be used to measure the construct by administering the questionnaire to a sample of the actual population. Other relevant established measures should be administered along with the new items. These measures are those that are correlated with or independent from the construct under examination, and are thus useful in assessing criterion-related validity.

(3) *Initial item reduction (Scale purification):* Items deemed conceptually inconsistent via factor analysis should be deleted. A factor loading of 0.4 or greater on the appropriate factor with no major cross-loadings is considered meaningful. Harvey et al. (1985) suggested that at least four items are needed to test the homogeneity of each latent construct.

(4) *Confirmatory factor analysis (CFA):* CFA allows the researcher to quantitatively assess the quality of the factor structure, thereby providing further evidence of the new measure's construct validity.

(5) *Reliability and validity assessment:* Reliability and validity assessment should include an assessment of internal consistency reliability and convergent, discriminant, and criterion-related validity. Use of the multitrait-multimethod matrix (MTMM) is a well-accepted technique for establishing

Table 2
Factors related to mobile service quality.

Author	Title	Factor related to mobile service quality
Turel and Serenko (2006)	Satisfaction with mobile services in Canada: An empirical investigation	• Perceived quality
Wang and Liao (2007)	The conceptualization and measurement of m-commerce user satisfaction	• Content quality • Service quality
Kumar and Lim (2008)	Age differences in mobile service perceptions: Comparison of Generation Y and baby boomers	• Functional quality • Mobile service quality • Billing service • Consumer service
Kuo et al. (2009)	The relationships among service quality, perceived value, customer satisfaction, and post-purchase intention in mobile value-added services	• Content quality • Navigation and visual design • Management and customer service • System reliability and connection quality
Lu et al. (2009)	A multidimensional and hierarchical model of mobile service quality	• Interaction quality • Environment quality • Outcome quality
Denga et al. (2010)	Understanding customer satisfaction and loyalty: An empirical study of mobile instant messages in China	• Service quality
Akter et al. (2010)	Service quality of m-health platforms: Development and validation of a hierarchical model using PLS	• Service reliability • System efficiency • System availability • System privacy • Responsiveness • Assurance • Empathy • Functional benefit • Emotional benefit
Santouridis and Trivellas (2010)	Investigating the impact of service quality and customer satisfaction on customer loyalty in mobile telephony in Greece	• Value-added services • Customer service • Pricing structure • Billing system

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Table 3
Summary of steps in developing M-S-QUAL.

Hinkin's (1998) steps	The specific-details of current study
Step 1 Item Generation	• Deductive approach • Literature reviews and synthesis • Content validity assessment
Step 2 Questionnaire Administration	• Pretest sample: 96 valid subjects ◆ Reliability: Cronbach's alpha ◆ Exploratory factor analysis (EFA) • Content validity assessment • Administering a formal questionnaire
Step 3 Initial Item Reduction	• Sample: 578 Internet users • Item-to-total correlations analysis • Exploratory factor analysis (EFA) • Reliability: Cronbach's alpha
Step 4 Confirmatory Factor Analysis	• Sample: same as step 3 • Confirmatory factor analysis (CFA)
Step 5 Convergent/ Discriminant Validity	• Reliability: Cronbach's alpha • Composite reliability (CR) • Average variance extracted (AVE) • Discriminant validity • Criterion-related validity
Step 6 Replication	• None

convergent and discriminant validity. However, CFA using structural equation modeling has become more popular in recent years, and may eventually replace MTMM.

(6) *Replication:* In replication stage, it is appropriate to collect new data set to repeat the scale-testing process with the new instrument. The replication should include an assessment of internal consistency reliability and convergent, discriminant, and criterion-related validity. These analyses provide the researcher with stronger evidence of the soundness of the new measurement scale.

3.1. Item generation

Both the original E-S-QUAL and subsequent E-RecS-QUAL (Parasuraman et al. 2005) provided the foundation for the questionnaire developed in this study. As previously noted, E-S-QUAL is a 22-item scale that measures electronic service quality in four factors: *efficiency*, *fulfillment*, *system availability*, and *privacy*. E-RecS-QUAL is salient to consumers who have non-routine encounters with a website, containing 11 items in three factors: *responsiveness*, *compensation*, and *contact*. As a new type of e-commerce, m-commerce provides a context in which consumers use various types of mobile devices to shop online. Those who use mobile service applications form opinions about their usefulness, ease of use, launch speed, and functions. Thus, the technical quality factor of E-S-QUAL had to be expanded to include the technical aspects of mobile services.

The original 22-item SERVQUAL scale developed by Parasuraman et al. (1988) forms the foundation of M-S-QUAL, although we modified certain descriptions to suit the mobile service context. Moreover, there are a number of behavioral differences between e-commerce and m-commerce customers. The former buy products or services online because doing so is convenient or can save them time and money. However, in the m-commerce context, in addition to all of the conveniences offered by e-commerce, customers are also attracted by the any-time, any-place proposition. Further, a number of new types of virtual products, such as applications (apps) and ring tone downloads, are seen only in m-commerce. Hence, unlike traditional e-commerce, in which physical products dominate, m-commerce features a proliferating range of virtual products. Accordingly, the questionnaire developed in this study was designed to assess the m-commerce shopping experience for both physical and virtual products. For example, virtual products can be delivered by a download that is completed within a matter of minutes, whereas the delivery of physical products involves physical transport and may take several days.

3.1.1. Developing a preliminary scale

Hinkin's (1998) guide to scale development specifies that items be generated using a deductive approach based on a theoretical foundation. Existing studies of m-commerce satisfaction, consumer loyalty, and mobile service quality are good sources of scale items. The service quality-related constructs found in the extant literature include perceived expectations, perceived quality, and perceived value. Turel and Serenko (2006) used the perceived expectations construct to represent both previous service experience and forward-looking beliefs about a service provider's ability to offer the desired quality. Perceived quality is the market's evaluation of recent service usage experience, and is derived from the degree of personalization and service reliability. Finally, perceived value is the price factor of perceived quality, and addresses the perception of value for money. As we did not consider customers' pre-use expectations of service quality, we did not adopt the perceived expectations construct in this study. However, even though E-S-QUAL does not encompass the price factor of perceived quality, we considered it to be necessary in assessing m-commerce quality because accessing mobile services often means paying extra on top of the traditional cost of e-commerce.

In comparison with E-S-QUAL, the proposed M-S-QUAL scale contains a number of additional factors and items, such as *billing* and *content*. The billing issues in m-commerce differ from those in e-commerce, and the payment method usually does too. Moreover, because mobile services have more varied content than e-services, it is important to assess the content richness of a mobile site. The research model in Fig. 3 lists the factors we used to measure our mobile service quality construct. Our initial scale included 51/49 items of the mobile service quality domain formed our initial scale of physical/virtual products shopping scope. These 51/49 items cover nine factors, each of which is defined briefly below the figure and summarized in Appendix B.

3.2. Pretesting

A pretest questionnaire survey was administered to ensure the quality of our scale instrument. The participants in this survey were undergraduate students. Of the 140 questionnaires distributed, 118 were completed and returned. These responses were further screened to omit respondents with less than one month's experience using mobile services, a process that yielded 96 valid responses. Exploratory factor analysis (EFA) was also performed in the pretest phase to reduce the items to a manageable and meaningful set of factors, and the internal consistency reliability was measured using Cronbach's alpha. Six items were deleted respectively for each product in this stage based on the criteria that one-factor loading should be more than 0.7 and that there be no cross-loadings.

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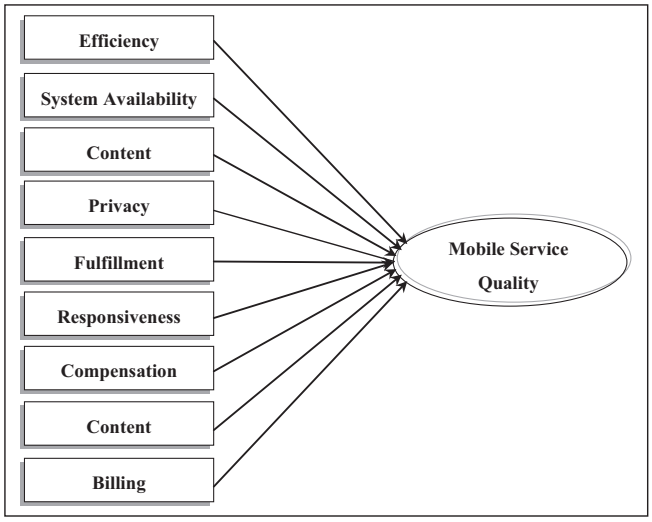

Fig. 3. Research model. Efficiency: Whether the site responds quickly and is easy to use. System Availability: Whether the required technical functions are readily available and the service promises are accurate. Content: Whether the information on the mobile site is appropriate and correct. Fulfillment: The extent to which the site's promises about order delivery and item availability are fulfilled. Privacy: The degree to which customers perceive the site to be safe and the extent to which their personal information is protected. Responsiveness: The effectiveness of the site's problem-handling process and return policy. Compensation: The degree to which the site compensates consumers for any problems they encounter. Contact: The availability of telephone assistance and online representatives. Billing: Perceived value for money and the convenience of the billing process.

3.3. Questionnaire administration

The survey was conducted in Taiwan. The questionnaire was designed to first ask the respondents whether they had used mobile services on handheld mobile devices. Only those replying in the affirmative were asked to continue filling out the self-administered multiple-item questionnaire survey. As m-commerce is on the rise and has not yet reached maturity, the respondents in this study were early adopters of mobile services. Although late adopters are not characterized by the enthusiasm usually found in early adopters, understanding early adopters' perceptions makes it much easier to bridge to the majority market of late adopters in the future.

Due to the early stage of m-commerce development, the questionnaire had to be set up where adopters gather. We conducted a survey by posting a link to the web questionnaire on the PTT Bulletin Board System (PTT, at http://www.ptt.cc/bbs/index.html). This system is the largest online forum in Taiwan, with more than 1.5 million registered users and over 200,000 discussion boards for various topics. On average, more than 40,000 articles and 1 million comments are posted on PTT every day. Three of these popular discussion boards, "iPhones," "Android-based phones," and "Windows phones," are highly relevant to our paper and were selected for our data collection. The contents of the discussions are quite diverse, ranging from features to prices to problem solving. Taiwan is home to many global communication technology products manufacturers. The intensity of high-tech industry in Taiwan has nurtured a market that readily embraces mobile technology and services. With a high penetration of smartphones and large m-commerce population, Taiwan is a suitable environment for conducting this study. According to Hinkin's recommendation (Hinkin 1998; p. 111), a minimum of 200 samples are required for confirmatory analysis. Therefore, we set a goal of collecting at least 300 samples for each type of shopping experience, physical and virtual product shopping.

It took two weeks to gather 702 responses, which were then further screened by how long the respondents had been using mobile services. Only those who answered "more than three months" were considered valid responses. We considered the elimination of less experienced users to be necessary because such users may not understand the concept of service quality in this context and may be subject to honeymoon bias. Of the initial 702 responses received, 578 (82%) were deemed valid. Of the initial 702 responses received, 578 (82%) were valid. To assess the non-response bias, we compared the responses in the early stage and those in the later stage. The results showed that there were no differences between these two groups on educational background ($\chi^2_4 = 1.088$, $p > 0.1$), job tenure ($\chi^2_8 = 8.740$, $p > 0.1$), and monthly disposable income ($\chi^2_5 = 7.620$, $p > 0.1$), which shows that non-response bias was of little concern. Respondents were instructed to answer the questions by recalling either their best or worst mobile service experience. The responses were categorized according to whether the mobile service in question pertained to a physical or virtual product purchase. Respondents evaluated mobile service quality by indicating their level of agreement with each statement on a five-point Likert scale.

The questionnaire also solicited respondents' demographic information. The descriptive statistics of the demographic variables show that the sample is composed of 338 (58.5%) males and 240 (41.5%) females. Among the respondents, 89.6% were between the ages of 21 and 35, meaning that about 10% were younger than 21 or older than 35. Some 94.6% of the respondents held a bachelor's or master's degree, which reflects the highly educated population in Taiwan.[3] In addition, 95% of the sample had less than 11 years of working experience, and 66.7% had a monthly disposable income of NT$20,000 or less. Thus, the sample of our study represents a group of young professionals, which is consistent with the current mobile device user profile in Taiwan.

Most respondents answered the questionnaire based on an m-commerce experience involving a smartphone (73.9%), meaning less than 30% of the respondents use other types of handheld devices to conduct mobile shopping. For the time being, smartphones may be the most convenient type of mobile devices to conduct mobile shopping. Using tablet PC and featured phone for mobile shopping is less common but possible. It will not be too surprising that mobile wearable devices can also be used for mobile shopping in the future. Further, 488 (84.43%) answered according to their experience of virtual product shopping and 90 (15.57%) answered according to their experience of physical product shopping. The substantial difference between virtual and physical product shopping in the responses reflects the status quo of m-commerce.

3.4. Item simplification and content validity establishment

The initial set of items was subjected to content validity assessment, with the result of a pretest allowing for the deletion of items deemed conceptually inconsistent. We invited 10 e-commerce researchers to help us assess content validity. They were provided with construct definitions and asked to match items with the corresponding definition. The items and constructs were arranged as the rows and columns of a checklist. The participating experts were instructed to check off the "no matching definition" column for items that did not correspond to any construct definition. An agreement index, which was the percentage of experts who correctly classified an item, was then calculated to assess content validity. Mackenzie et al. (1991) suggested a minimum of 75% agreement for acceptable content validity. Items that are retained

[3] In Taiwan, more than 90% of high school graduates enter colleges.

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represent a reasonable measure of the construct under examination and reduce the need for subsequent scale modification.

4. Data analysis and scale purification

4.1. Scale purification

In this study, we performed descriptive statistical analysis, item correlation analysis, EFA, and CFA, thereby firmly establishing the scale's reliability and validity. Quantitative analysis of the questionnaire was conducted using SPSS18 and AMOS18 software. This study used SPSS AMOS to analyze the data for the purposes of confirming the structure of the measurement scale, conducting path analysis, and testing the model fit. Although approaches like PLS-PA or systems of regression equations can be used for path analysis, they do not conveniently contain all the necessary algorithms, for example, fit algorithms. As explained in Westland (2014), AMOS-LISREL type tools provide fit algorithms, while PLS-PA tools do not. Westland (2014) also pointed out that PLS-PA analyses are primarily exploratory analysis tools, thus they do not suffice our purpose of scale construction. As AMOS tends to work well only for normally distributed sample data (Westland, 2014), the survey data was checked for Normal distribution conformity. The Q–Q plots in Appendix C showed that the distributions of all observations are visually Normal. The calculation of skew and kurtosis coefficients further affirm that the survey data are suitable for analyses requiring normally-distributed data: the absolute value of skew coefficients were less than 3 (with the highest being 0.897) and the absolute value of kurtosis coefficients were less than 8 (with the highest being 0.932). These are the recommended thresholds for checking whether the Normal distribution requirement in SEM analysis is met (Kline 2005; p. 49–52). Descriptive statistical analysis was used to summarize the characteristics of the respondents and the data for all variables. Item analysis is fundamental to the establishment of scale reliability, and missing value analysis was conducted to ensure the integrity of the data, after which corrected item-total correlation analysis was carried out. This analysis is based on the correlations between individual items relative to the items' total variances. Items that are inconsistent with the average behavior of other items are deleted. The value of the corrected item-total correlation should be greater than 0.7. Item analysis is undertaken before EFA, which determines the possible factors of the construct. In this study, after completing item analysis, EFA was performed to establish the factor structure of each construct and to reduce the set of observed variables to a smaller variable set. A factor loading of 0.4 was used as the threshold to further eliminate items. Finally, CFA was undertaken to confirm the factor structure extracted by EFA and to assess both convergent and discriminant construct validity. In the confirmatory stage, with the number of items in the measurement scales, a more accurate estimation of adequate sample sizes can be calculated by Westland's (2010) formulas, and Bentler's (1989) and Bollen's (1989) rules of AMOS-LISREL analysis. Under the default condition "anticipated effect size: 0.1, desired statistical power level: 0.8, probability level: 0.05", the minimum sample sizes for the AMOS analysis of physical and virtual product shopping experiences are 387 and 463, respectively, confirming that our sample sizes of 390 (with bootstrap resampling) and 488 are adequate.

4.1.1. Item analysis

The scale items (45 for measuring support services for physical product shopping and 43 for measuring support services for virtual product shopping) were refined by analyzing the data collected from mobile handheld device users who had experience in using these devices to shop for either physical or virtual products. The first step in purifying the instrument was to delete items based on Cronbach's α and the corrected item-total correlations (Cronbach 1951). The item-total correlation test is used to check whether any item within the construct is irrelevant. It helps to purify the measure by eliminating "garbage items" before determining the construct factors, avoiding the production of too many factors in the later factor analysis stage (Churchill 1979). All of the measurement items chosen had corrected item-total correlations equal to or greater than 0.70. This is significantly rigorous, as cut-off points of 0.5 or even 0.3 are often accepted (Saxe and Weitz 1982). The Cronbach's α values were then recalculated. Three items were eliminated (one item for support services for physical product shopping and two items for support services for virtual product shopping) through the iteration, resulting in a 44-item scale for measuring physical product M-S-QUAL and a 41-item scale for measuring virtual product M-S-QUAL.

4.1.2. Identifying the factor structure of M-S-QUAL

EFA was conducted to examine the factor structure of the 44- and 41-item instruments in more detail. The two sets of data were analyzed separately: one concerning support services for physical product shopping (90 valid responses) and the other concerning support services for the virtual product shopping (488 valid responses). The Kaiser–Meyer–Olkin (KMO) and Bartlett's sphericity test produced a KMO measure greater than 0.7 and a significant Bartlett's sphericity test result, indicating that the inter-correlation matrix contained a sufficient degree of common variance, and thus that EFA should be performed.

4.2. Exploratory factor analysis (EFA)

EFA, using principal component analysis as the extraction technique and the varimax orthogonal as the rotation method, was conducted to identify the dimensionality of the 44- and 41-item scales. We extracted factors with eigenvalues greater than or equal to 1, yielding four factors concerning support services for the physical product shopping and five factors concerning support services for the virtual product shopping. Three guidelines were followed in identifying the factors underlying M-S-QUAL: (1) delete items with a factor loading less than 0.7 or loadings greater than 0.3 on two or more factors; (2) maintain a simple factor structure; and (3) exclude single-item factors in the interests of parsimony (Hinkin 1998; Straub 1989).

Three iterative runs based on these guidelines resulted in the deletion of 29 support service items from the physical product shopping. The factor analysis procedure yielded a 4-factor, 15-item instrument. The four factors, which explained 81.34% of the variance in the dataset, were efficiency, fulfillment, contact, and responsiveness. The sample size (90) for the category of support services for physical product shopping was not sufficiently large to conduct the subsequent CFA step, for which the recommended minimum sample size is 200 (Holeter 1983). Therefore, bootstrap resampling (300 resamples) was performed to determine the significance of the path coefficients in CFA. Table 4 summarizes the factor loadings for the condensed 15-item instrument for the service quality measurement of physical product shopping. EFA was also undertaken for the virtual product M-S-QUAL following the same guidelines, which resulted in the deletion of 22 items, giving us a 5-factor, 19-item instrument and enabling us to proceed to CFA (see Table 5). The result showed each item to load heavily on one factor, thus assuring convergent validity. The instrument's discriminant validity was supported by the low cross-loadings (<0.3).

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4.3. Confirmatory factor analysis (CFA)

The purpose of the CFA undertaken at this stage was to test whether the factors resulting from EFA were appropriate indicators of mobile service quality. The factor structure extracted by EFA had to be confirmed by constructing a measurement model and then linking it with the valid sample data to calculate the path coefficients and model fit. For each latent variable, items with low indicator coefficients (below 0.7) were deleted, and model fit was checked again. The procedure continued iteratively until good model fit was achieved.

CFA is a structural equation modeling technique that tests whether the data fit the measurement model. It allows for the existence of measurement errors or residuals between exogenous and endogenous variables. Modification indices suggest remedies for discrepancies between the proposed and estimated model. However, in this study, adding regression lines to correct the model fit would accomplish little, as all of the regression lines between the latent and observed variables were already in place. We thus looked at the modification indices for covariances in CFA. We could not co-vary the error terms with the observed or latent variables or with other error terms that were not part of the same factor. Hence, the only modification available to us was to co-vary the error terms that were part of the same factor.

The other model adjustment method depends on standardized residual covariances among the observed variables. If the values of these covariances are too high (higher than 2), the items could be considered for deletion. All three methods were executed until the model fits were good. The final model confirmed all model paths, thus indicating a good degree of fit between the model and the data. We ultimately obtained a 4-factor, 15-item instrument for physical product shopping and a 5-factor, 16-item instrument for virtual product shopping, and then used standardized factor loadings to calculate the composite reliability and average

Table 4
Factor loadings for 15-item shopping experience of physical product M-S-QUAL ($N = 90$).

Factor	Items	Efficiency	Fulfillment	Contact	Responsiveness
Efficiency	This site enables me to access it quickly	**0.880**	0.166	0.225	0.178
	It enables me to complete a transaction quickly	**0.858**	0.286	0.230	0.146
	It loads its pages quickly	**0.826**	0.178	0.210	0.244
	Pages at this site do not freeze after I enter my order information	**0.804**	0.267	0.208	0.207
	This site does not crash	**0.704**	0.194	0.203	0.191
Fulfillment	This site makes items available for delivery within a suitable timeframe	0.158	**0.894**	0.082	0.296
	It sends out the items ordered	0.243	**0.826**	0.194	0.253
	It delivers orders when promised	0.210	**0.791**	0.183	0.257
	It is truthful about its offerings	0.280	**0.744**	0.104	0.028
Contact	Service agents provide consistent advice	0.268	0.156	**0.838**	0.221
	It offers the ability to speak to a live person if there is a problem	0.284	0.110	**0.820**	0.210
	This site provides a telephone number to reach the company	0.259	0.215	**0.789**	0.199
Responsiveness	It provides me with convenient options for returning items	0.261	0.279	0.195	**0.811**
	This site handles product returns well	0.284	0.230	0.224	**0.767**
	This site offers a meaningful guarantee	0.215	0.245	0.265	**0.766**
Eigenvalue		8.50	1.85	1.57	1.00
Variance explained (%)		55.46	66.59	75.92	81.34

Note: The bold values show that the values are the largest ones on their corresponding rows.

Table 5
Factor loadings for 19-item shopping experience of virtual product M-S-QUAL ($N = 488$).

Factor	Items	Contact	Responsiveness	Fulfillment	Privacy	Efficiency
Contact	Call-center personnel is able to help with problems	**0.855**	0.164	0.174	0.200	0.196
	Service agents provide consistent advice	**0.832**	0.172	0.151	0.196	0.248
	It picks up items I want to return from my home or business	**0.825**	0.202	0.130	0.221	0.260
	It offers the ability to speak to a live person if there is a problem	**0.819**	0.123	0.218	0.133	0.221
	Friendliness when making a complaint	**0.811**	0.143	0.206	0.197	0.279
	This site provides a telephone number to reach the company	**0.796**	0.155	0.235	0.182	0.193
Responsiveness	This site offers a meaningful guarantee	0.210	**0.906**	0.129	0.137	0.140
	This site handles product returns well	0.221	**0.906**	0.161	0.116	0.122
	It provides me with convenient options for returning items	0.262	**0.898**	0.113	0.119	0.086
Fulfillment	This site makes items available for delivery within a suitable timeframe	0.111	0.130	**0.890**	0.204	0.102
	It delivers orders when promised	0.145	0.008	**0.888**	0.139	0.079
	It has in stock the items the company claims to have	0.248	0.162	**0.805**	0.187	0.158
	It quickly delivers what I order	0.172	0.229	**0.782**	0.283	0.134
Privacy	It does not share my personal information with other sites	0.227	0.135	0.125	**0.865**	0.139
	It protects information about my web-shopping behavior	0.222	0.144	0.173	**0.823**	0.221
	This site protects my credit card information	0.201	0.173	0.093	**0.795**	0.140
Efficiency	It loads its pages fast	0.285	0.275	0.150	0.139	**0.841**
	This site enables me to access it quickly	0.272	0.245	0.154	0.200	**0.830**
	It enables me to complete a transaction quickly	0.249	0.216	0.124	0.168	**0.825**
Eigenvalue		9.53	2.33	2.08	1.17	1.1
Variance explained (%)		49.15	60.35	70.36	75.60	80.39

Note: The bold values show that the values are the largest ones on their corresponding rows.

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variance extracted (AVE) of each construct to verify convergent validity (Tables 4 and 5).

The final model confirmed all model paths, thus indicating a good degree of fit between the model and the data. As shown in Tables 6 and 7, we ultimately obtained a 4-factor, 15-item instrument for physical product shopping and a 5-factor, 16-item instrument for virtual product shopping, and then used standardized factor loadings to calculate the composite reliability and average variance extracted (AVE) of each construct to verify convergent validity. The questionnaire items in Tables 6 and 7 are our final validated measurement scale.

Several model fit indices are used to assess how well a proposed model captures the covariance between all of its items or measures. The recommended values for goodness-of-fit and the CFA results in this study are summarized in Table 8. Figs. 4 and 5 are the graphs of analysis results concerning support services for the two processes of physical and virtual product shopping. The overall structural fit results of these analyses demonstrate that the proposed model provides a reasonable degree of fit. The 15-item, four-factor confirmatory factor model for physical product shopping experience resulted in a significant chi-square value ($\chi^2_{84} = 120.269$, $p < .00$), with RMSEA, GFI, AGFI, NFI, and CFI values of 0.07, 0.94, 0.91, 0.91, and 0.97, respectively. The 16-item, five-factor confirmatory factor model for virtual product shopping experience resulted in a significant chi-square value ($\chi^2_{92} = 232.675$, $p < .00$), with RMSEA, GFI, AGFI, NFI, and CFI values of 0.06, 0.95, 0.92, 0.97, and 0.98, respectively. Both of the CFA results revealed excellent overall fit.

4.4. Reliability and validity assessment

Reliability assessments measure the internal consistency and stability of a measurement instrument. Cronbach's α coefficients, commonly used estimates of reliability, over the threshold of 0.7 indicate strong item covariance. Validity refers to the degree to which the instrument correctly measures the construct. The following sections and tables report the reliability and convergent, discriminant, and criterion-related validity of the M-S-QUAL instruments.

4.4.1. Reliability

Cronbach's α was used to evaluate the instruments' reliability by assessing the internal consistency of the items representing each factor. Table 9 summarizes the results of the Cronbach's α calculations, which show a very high degree of reliability for all factors.

Table 6
CFA and reliability results (physical products shopping experiences).

Factor	Items	Factor loadings	Composite reliability	Average variance extracted
Efficiency	It enables me to complete a transaction quickly	0.945	0.9536	80.49
	It loads its pages quickly	0.917		
	This site enables me to access it quickly	0.932		
	This site does not crash	0.789		
	Pages at this site do not freeze after I enter my order information	0.894		
Fulfillment	It delivers orders when promised	0.880	0.9333	77.85
	This site makes items available for delivery within a suitable timeframe	0.932		
	It sends out the items ordered	0.922		
	It is truthful about its offerings	0.788		
Contact	Service agents provide consistent advice	0.884	0.9354	82.86
	It offers the ability to speak to a live person if there is a problem	0.956		
	This site provides a telephone number to reach the company	0.889		
Responsive	It provides me with convenient options for returning items	0.884	0.9315	81.93
	This site handles product returns well	0.911		
	This site offers a meaningful guarantee	0.920		

Table 7
CFA and reliability results (virtual products shopping experiences).

Factor	Items	Factor loadings	Composite reliability	Average variance extracted
Efficiency	This site enables me to access it quickly	0.90	0.939	83.79%
	It enables me to complete a transaction quickly	0.91		
	It loads its pages quickly	0.93		
Fulfillment	It quickly delivers what I order	0.92	0.924	80.26%
	It delivers orders when promised	0.88		
	This site makes items available for delivery within a suitable timeframe	0.88		
Privacy	This site protects my credit card information	0.88	0.930	81.59%
	It protects information about my web-shopping behavior	0.91		
	It does not share my personal information with other sites	0.93		
Contact	Friendliness when reporting a complaint	0.92	0.916	78.36%
	Service agents provide consistent advice	0.92		
	It offers the ability to speak to a live person if there is a problem	0.82		
	This site provides a telephone number to reach the company	0.80		
Responsive	It provides me with convenient options for returning items	0.92	0.956	87.81%
	This site handles product returns well	0.94		
	This site offers a meaningful guarantee	0.94		

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Table 8
Model's goodness-of-fit indices. (n = 488, virtual products; n = 90, bootstrap resampling, physical products).

Model fit indices	Criterion guidelines	CFA results (virtual products)	CFA results (physical products)
Chi-square		232.675	120.269
Degrees of freedom		92	84
Absolute fit measures			
GFI	>.80 (MacCallum and Hong 1997)	0.945	0.936
RMSEA	<.10 (Steiger 1990)	0.056	0.07
SRMR	<.05 (Jöreskog and Sörbom 1992)		
Normed chi-square/df	<3 (Hair et al. 2010)	2.529	1.432
Incremental fit measures			
NFI	>.90 (Bentler 1992)	0.97	0.91
CFI	>.90 (Gerbing and Anderson 1992)	0.982	0.97
Parsimony fit measure			
AGFI	>.80 (MacCallum and Hong 1997)	0.918	0.909

Note: GFI, goodness of fit index; RMSEA, root mean squares error of approximation; SRMR, standardized root mean square residual; NFI, normed fit index; CFI, comparative fit index; AGFI, adjusted goodness of fit index.

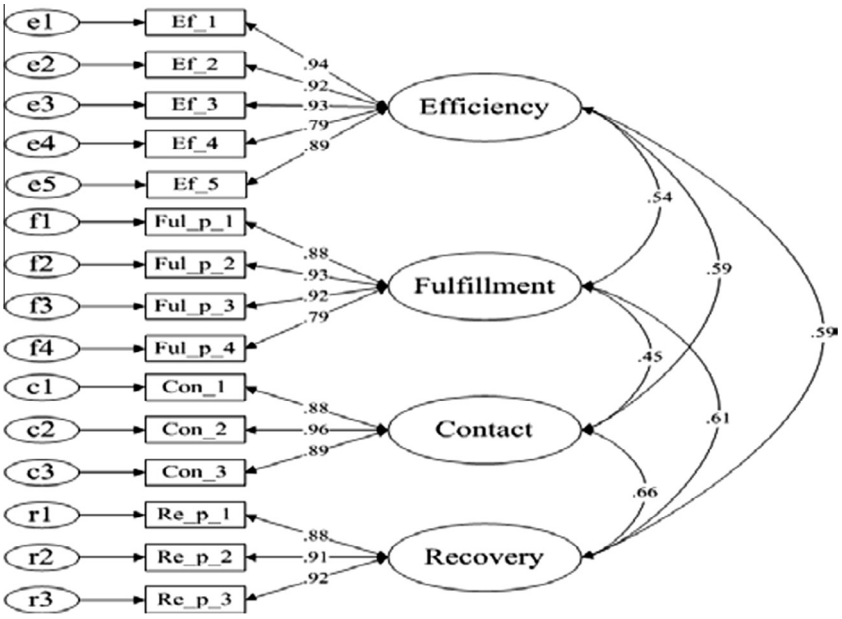

Fig. 4. Test of the mobile service quality dimensions (physical products shopping experiences).

4.4.2. Convergent and discriminant validity

The standardized factor loadings and AVE values of each factor were used to verify convergent validity. For each factor, the standardized factor loading was above the threshold of 0.7 (Barclay et al. 1995) and the AVE was higher than 0.5 (Fornell and Larcker 1981). The composite reliability of each factor was also above the recommended value of 0.7 (Bagozzi and Yi 1988). Both the factor loadings and AVE values confirmed that the instruments had good degrees of convergent validity, as shown in Tables 6 and 7.

To examine the discriminant validity of an instrument, the squared correlation coefficients and AVE are usually compared. If the AVE of a factor is greater than its squared correlation coefficients with other factors, then that factor is effectively discriminant from other factors (Fornell and Larcker 1981). If the condition is consistent across all factors, then good discriminant validity is confirmed. Alternatively and equivalently, the correlation coefficients can be compared with the square roots of the AVE values. We used both methods in this study. Tables 10 and 11 present the correlations among the factors and the AVE values of each factor, with the square roots of those values shown along the diagonal in bold. These results demonstrate the good discriminant validity of the instruments.

4.4.3. Criterion-related validity

A criterion is essentially a variable that is related to the measurement construct in a nomological network. Criterion-related validity is assessed by whether the measurement construct and its criterion variables are highly correlated. A scale with good criterion-related validity has strong relationships with its criterion variables.

In the case of M-S-QUAL, a relevant manifestation of criterion-related validity would be the extent to which the factors, which are conceptually linked to mobile service use, actually predict a user's mobile usage behavioral intentions. That extent can be evaluated by regressing users' value perceptions and loyalty intentions on the M-S-QUAL factors. As in Parasuraman et al. (2005), perceived value and loyalty intention were selected as the criterion variables. Our measures of these variables were also adapted from those in Parasuraman et al. (2005).

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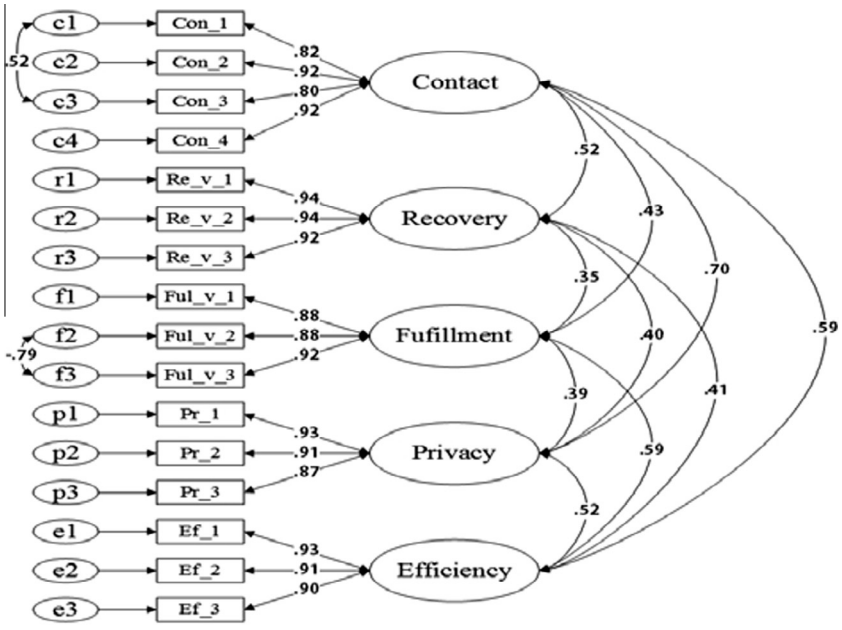

Fig. 5. Test of the mobile service quality dimensions (virtual products).

Table 9
Cronbach's α for each factor.

Factors	Physical products shopping experiences		Virtual products shopping experiences	
	Number of items	Cronbach's α	Number of items	Cronbach's α
Efficiency	5	0.953	3	0.939
Fulfillment	4	0.932	3	0.902
Contact	3	0.935	3	0.931
Responsiveness	3	0.931	4	0.955
Privacy	–	–	3	0.929

Table 10
Correlations and square roots of AVEs (physical products shopping experiences).

	Efficiency	Contact	Fulfillment	Responsiveness
Efficiency	**0.89**			
Contact	0.57**	**0.90**		
Fulfillment	0.52**	0.42**	**0.87**	
Responsiveness	0.56**	0.60**	0.56**	**0.9**

Note: The numbers in bold are the square roots of the AVEs. The off-diagonal elements are the correlations among the factors.
** $p < 0.01$.

There are four factors concerning physical product shopping process, and five factors concerning virtual product shopping process. Before regression analysis, collinearity analysis was conducted, with variance inflation factor (VIF) values calculated to ensure that the multicollinearity problem was minimal. The VIF values were all less than 2, far below the cutoff value of 10 (Hair et al. 2010), thus indicating a low level of multicollinearity.

A seven-point Likert-type scale ranging from "strongly disagree" to "strongly agree" was used to measure perceived value and loyalty intention. The Cronbach's alphas were 0.97 and 0.95, respectively. The results of regression analysis for both physical and virtual product shopping experiences are presented in Tables 12 and 13, respectively. In both contexts, the relationships between the various factors of M-S-QUAL and the criterion variables were confirmed, and the R^2 values were all relatively high. The instrument was thus concluded to be of good criterion-related validity.

5. Discussion and conclusion

In this paper, we tested a model of mobile service quality, the M-S-QUAL, by using both EFA and CFA. The proposed model comprises nine factors obtained by deduction. Some of the items in the initial scale were deleted as a result of the EFA in the pre-test stage

Table 11
Correlations and square roots of AVEs (virtual products shopping experiences).

	Efficiency	Privacy	Contact	Fulfillment	Responsiveness
Efficiency	**0.91**				
Privacy	0.49**	**0.90**			
Contact	0.55**	0.65**	**0.88**		
Fulfillment	0.56**	0.37**	0.40**	**0.89**	
Responsiveness	0.39**	0.37**	0.50**	0.33**	**0.93**

Note: The numbers in bold are the square roots of the AVEs. The off-diagonal elements are the correlations among the factors.
** $p < 0.01$.

Please cite this article in press as: Huang, E.Y., et al. M-S-QUAL: Mobile service quality measurement. Electron. Comm. Res. Appl. (2015), http://dx.doi.org/10.1016/j.elerap.2015.01.003

Table 12
Regression of criterion variables on factors for physical products shopping experiences.

Factors of M-S-QUAL	Criterion variables	
	Perceived value	Loyalty intention
Efficiency	0.43**	0.15
Fulfillment	0.39**	0.40**
Contact	0.16*	0.15
Responsiveness	0.01	0.16*
R^2	0.67	0.51

* $p < 0.05$.
** $p < 0.01$.

Table 13
Regression of criterion variables on factors for virtual products shopping experiences.

Factors of M-S-QUAL	Criterion variables	
	Perceived value	Loyalty intention
Efficiency	0.27**	0.30**
Fulfillment	0.06	−0.01
Contact	0.26**	0.35**
Responsiveness	0.25**	0.19*
Privacy	−0.19	0.39**
R^2	0.72	0.68

* $p < 0.05$.
** $p < 0.01$.

and in the subsequent CFA using survey data. After deleting certain items and even entire factors from the initial item pool, the procedure followed in this paper produced a 15-item, 4-factor instrument for the physical product shopping experience component of the M-S-QUAL, and a 16-item, 5-factor instrument for the virtual product shopping experience component of the M-S-QUAL. From the original set of factors, content, compensation, privacy and billing were eliminated from the instrument which measures physical product shopping experience. The factors of content, compensation and billing were omitted from the instrument which measures virtual product shopping experience. The structure of the items making up each instrument was determined, and both instruments proved to have high degrees of reliability and validity. The goodness-of-fit between the proposed model and the survey data was also confirmed.

At first glance, it may seem surprising that various factors were removed in the scale construction process. The removed factors used to be important criteria for shoppers' assessments of sellers' service quality, which is why they were identified in the extant e-commerce literature. However, as consumers have grown more demanding in the e-commerce and m-commerce environments, many incompetent sellers have been eliminated from the new business arena. Due to the fiercer competition compared with the e-commerce environment years ago, marketers in the mobile commerce era are now allowed fewer chances to make up for mistakes or to compensate consumers for unsatisfactory dealings. These shifts in the market make factors such as content, compensation, privacy and billing the most indispensable service features, rather than some of the more traditional factors in evaluating service quality. In other words, the features we have identified are those that must be in place for the mobile commerce market. Sellers must adhere to business norms or standards regarding these factors if they wish to conduct business.

Interestingly, privacy remains an important factor in the measurement of virtual product shopping experience, but not in the case of physical product shopping experience. We offer the following possible reason: At present, the largest category of virtual products purchased through m-commerce consists of apps. In making such purchases, however, the location-based capability of mobile services and the app payment practices used in m-commerce may result in customers feeling less in control of their privacy in terms of their identity and their payment account details. The m-commerce shopping process for virtual products is rather different from that for physical products. The process for these virtual product transactions is usually quite seamless. The necessary payment information is customarily stored by sellers after the users set up their accounts. The payment transactions are then completed without the users being further prompted for the details of their names, phone numbers, addresses or credit card numbers. In contrast, when customers purchase physical products, they are usually required to enter the information for payment, or they have the chance to check the information stored in the seller's database. Such explicit information delivery and confirmation may increase the users' confidence that everything is in control. The difference in how transaction processes are set up for virtual products may be the reason that privacy emerges as an important factor in measuring the experience of virtual product shopping, but not in measuring the experience of shopping for physical products.

We speculate that weak effects or small samples in the case of measuring the physical product shopping experience may be the reasons for statistically insignificant tests. As the questionnaire items used in this study were summarized from the prior service quality literature, it is unlikely that these results are caused by inappropriate instrument items. At present, large sample collection in the m-commerce environment is not highly feasible, because virtual products currently dominate this market. Further verification of the physical product shopping experience component of the M-S-QUAL will be due when more physical products are sold through mobile platforms, and when more mobile users grow accustomed to making purchases of physical products with their mobile devices. This development is expected in the foreseeable future.

5.1. Theoretical and practical implications

This paper neither develops new theory nor modifies prior theory, but it does provide a foundation for new theory development. Although not a typical empirical research paper that tests relationships among variables, this paper develops a solid measurement scale, which is a foundation for further academic research. This paper makes several theoretical contributions to service quality measurement research. The previous development of this research area can be traced back several decades. However, due to the recent high penetration of mobile services, this paper identifies the need to construct a service quality measurement scale for m-commerce. In the final validated scale, several dimensions of service quality that were identified in previous studies are not present. This shift implies that the traditional notions of service quality do not adequately describe the needs and priorities of m-commerce shoppers. As the commerce environment is increasingly characterized by mobility, the concept of service quality needs to be largely redefined. Thus, this paper marks an important milestone in the understanding of service quality for the emerging m-commerce market.

By testing and validating the proposed model through rigorous psychometric scale development procedures and methodologies at each step, this paper provides empirical evidence that the M-S-QUAL scale is robust. To the best of our knowledge, this paper is the first to address the mobile service quality measurement issue for both physical and virtual product shopping processes. The results show that M-S-QUAL is very stable and demonstrates excellent scale quality. This paper is of both practical and theoretical significance, because businesses can confidently adopt this scale to conduct mobile service quality surveys, and academics can

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conveniently use it in a broad range of m-commerce research. Although not a typical empirical research paper that tests relationships among variables, this paper develops a solid measurement scale, which is a foundation for further academic research.

5.2. Limitations and future research directions

The rigorous validation procedure followed in this paper allowed us to develop an instrument for measuring mobile service quality as perceived by users when they purchase products in the mobile environment. In developing this instrument, we made a distinction between experiences of m-commerce shopping for virtual and for physical products. This distinction further ensures the M-S-QUAL instrument's applicability to both categories of mobile service. The sample used for instrument validation was drawn from mobile device users with m-commerce experience. At present, such users are generally young and do not belong to a high income bracket. In addition, heavy users are more likely to be men than women. This user profile is clearly reflected in the composition of our respondents, most of whom were male (58.5%) and had a monthly disposable income of less than NT$20,000 (66.7%). Using a sample of young people does not produce a sample bias, because current mobile shoppers (the population that the participants are drawn from) are indeed mainly young people. Therefore, the sample adequately represents the current population of users. These young people will become older as m-commerce reaches maturity. Knowing how they perceive service quality issues is crucial to understanding the more general mobile shopper population of the future.

In addition, because only a small percentage of respondents had purchased physical products in the m-commerce environment, the sample size for the physical product shopping experience component of the M-S-QUAL was sufficient only to conduct EFA to determine its factor structure. Hence, a bootstrap method was necessary to generate bootstrap samples for CFA. In the future, when physical product shopping becomes more common in the m-commerce environment, its support services should be re-examined with a larger sample, which would allow a CFA to be carried out directly.

Although this study was conducted in Taiwan, the potential bias due to differences in shoppers' profiles, as compared with other major m-commerce markets, is of minor concern. A comparison across three countries, Taiwan, the US, and Germany, assures us that the profiles are similar. Mobile shoppers in these countries are mostly young people in their 20s and 30s. The m-commerce markets in these countries are represented by a high percentage of mobile shoppers. Taiwan ranked first in users' reliant on smartphones and ranked second in mobile shopping frequency in the Asia–Pacific region (Google 2013). In the US region, 84 percent of mobile consumers have used their devices to shop in the first quarter of 2013 (Nielsen 2013). Germany has the biggest m-commerce market in Europe with about 10 million users (Research and Markets 2013).

However, when applying the instrument in other parts of the world, cultural differences should still be considered, especially if the shoppers are unusually sophisticated, or if the mobile shoppers' profiles differ from those characterized in this study. Thus, future studies could validate this instrument in other countries to increase the generalization and reliability of this scale.

Acknowledgments

This research was partially funded by the National Science Council, Taiwan, ROC, under contract number NSC 100-2410-H-004-026-MY2 and NSC 101-2410-H-031-009-MY2. The authors would also like to thank Professor Christopher Westland and anonymous reviewers for making the publication of this paper possible.

Appendix A.

Table A-1
SERVQUAL scale.

Tangibles	
E1	Excellent telephone companies will have modern-looking equipment
E2	The physical facilities at excellent telephone companies will be visually appealing
E3	Employees of excellent telephone companies will be neat-appearing
E4	Materials associated with the service (such as pamphlets or statements) will be visually appealing in an excellent telephone company
Reliability	
E5	When excellent telephone companies promise to do something by a certain time, they will do so
E6	When customers have a problem, excellent telephone companies will show a sincere interest in solving it
E7	Excellent telephone companies will perform the service right the first time
E8	Excellent telephone companies will provide their services at the time they promise to do so
E9	Excellent telephone companies will insist on error-free records
Responsiveness	
E10	Employees of excellent telephone companies will tell customers exactly when services will be performed
E11	Employees of excellent telephone companies will give prompt service to customers
E12	Employees of excellent telephone companies will always be willing to help customers
E13	Employers of excellent telephone companies will never be too busy to respond to customer requests
Assurance	
E14	The behavior of employees of excellent telephone companies will instill confidence in customers
E15	Customers of excellent telephone companies will feel safe in their transactions
E16	Employees of excellent telephone companies will be consistently courteous with customers
E17	Employees of excellent telephone companies will have the knowledge to answer customer questions
Empathy	
E18	Excellent telephone companies will give customers individual attention
E19	Excellent telephone companies will have operating hours convenient to all their customers
E20	Excellent telephone companies will have employees who give customers personal attention
E21	Excellent telephone companies will have the customers' best interests at heart
E22	The employees of excellent telephone companies will understand the specific needs of their customers

Table A-2
E-S-QUAL scale.

Efficiency		*Fulfillment*	
EFF1	This site makes it easy to find what I need	EFF1	It delivers orders when promised
EFF2	It makes it easy to get anywhere on the site	EFF2	This site makes items available for delivery within a suitable time frame
EFF3	It enables me to complete a transaction quickly	EFF3	It quickly delivers what I order
EFF4	Information at this site is well organized	EFF4	It sends out the items ordered
EFF5	It loads its pages fast	EFF5	It has in stock the items the company claims to have
EFF6	This site is simple to use	EFF6	It is truthful about its offerings
EFF7	This site enables me to get on to it quickly	EFF7	It makes accurate promises about delivery of products
EFF8	This site is well organized		
System availability		*Privacy*	
SYS1	This site is always available for business	PRI1	It protects information about my Web-shopping behavior

(continued on next page)

SYS2	This site launches and runs right away	PRI2	It does not share my personal information with other sites
SYS3	This site does not crash	PRI3	This site protects information about my credit card
SYS4	Pages at this site do not freeze after I enter my order information		

Table A-3
E-RecS-QUAL scale.

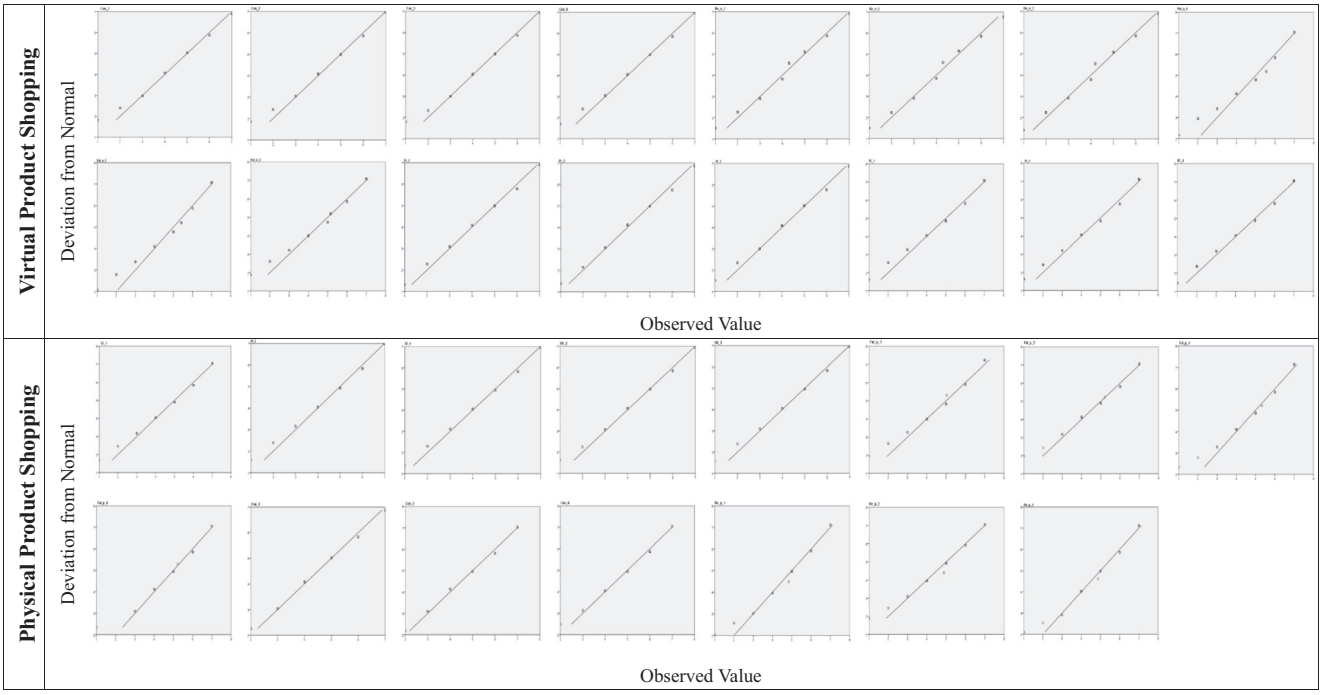
Responsiveness	
RES1	If provides me with convenient options for returning items
RES2	This site handles product returns well
RES3	This site offers a meaningful guarantee
RES4	It tells me what to do if my transaction is not processed
RES5	It takes care of problems promptly
Compensation	
COM1	This site compensates me for problems it creates
COM2	It compensates me when what I ordered doesn't arrive on time
COM3	It picks up items I want to return from my home or business
Contact	
CON1	This site provides a telephone number to reach the company
CON2	This site has customer service representatives available online
CON3	It offers the ability to speak to a live person if there is a problem

Appendix B.

Table B-1
The definitions and measurement items of mobile service quality in current study.

Dimensions	Definitions	Items
Efficiency	Whether the site responds quickly and is easy to use	1. This mobile site makes it easy to find what I need. 2. It is easy to get anywhere on the mobile site. 3. This site enables me to complete a transaction quickly. 4. Information at this mobile site is well organized. 5. The site loads its pages quickly. 6. This mobile site is simple to use. 7. This mobile site enables me to get on to it quickly. 8. This mobile site is well organized.
System availability	Whether the required technical functions are readily available and the service promises are accurate	1. This mobile site is always available for business. 2. This mobile site launches and runs right away. 3. This mobile site does not crash. 4. The pages at this mobile site do not freeze after I enter my order information.
Content	Whether the information on the mobile site is appropriate and correct	1. The content of the mobile website is concise. 2. The content of the mobile website is accurate. 3. This mobile website provides complete content. 4. This mobile website provides appropriate content. 5. This mobile website provides important content. 6. This mobile website provides fashionable content. 7. This mobile website provides regularly updated content. 8. I can fully understand the content provided.
Privacy	The degree to which customers perceive the site to be safe, and the extent to which their personal information is protected	1. This site protects information about my mobile-shopping behavior. 2. The site does not share my personal information with other mobile sites. 3. This mobile site protects information about my credit card.
Fulfillment	The extent to which the site's promises of order delivery and item availability are fulfilled	1. The site delivers orders when promised. 2. This mobile site makes items available for delivery within a suitable time frame. 3. The site quickly delivers what I order. 4. The site correctly sends out the items ordered. 5. The site has the items that the company claims to have in stock. 6. The site is truthful about its offerings. 7. The site makes accurate promises about delivery of products. 8. When the order is completed, the order information is sent in a timely fashion. 9. When order is completed, the service provider can provide customized information.
Responsiveness	The effectiveness of the site's problem-handling process and return policy	1. This mobile site provides me with convenient options for returning items. 2. This mobile site handles product returns well. 3. This mobile site offers a meaningful guarantee. 4. The site tells me what to do if my transaction is not processed. 5. This mobile site provides a telephone number to reach the company. 6. This mobile site has customer service representatives available online. 7. The site offers the option to speak with a live person if there is a problem.
Compensation	The degree to which the site compensates consumers for any problems they encounter	1. This mobile site compensates me for problems it creates. 2. The site compensates me when items I order do not arrive on time. 3. The company picks up items I want to return from my home or business.
Contact	The availability of telephone assistance and online representatives	1. The service agents are friendly when receiving complaints. 2. The service agents provide consistent advice. 3. The customer service representatives are polite. 4. The call center personnel are able to help with problems.
Billing	Perceived value for money and the convenience of the billing process	1. The mobile website provides convenient payment procedures. 2. The site provides accurate billing. 3. It easy to understand and resolve billing issues 4. The company resolves billing issues quickly. 5. The prices of the products and services available at this site are economical. 6. The site offers a variety of price schedules. 7. The site offers the possibility of freely choosing price schedules.

Appendix C. Q–Q plots of observations



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Please cite this article in press as: Huang, E.Y., et al. M-S-QUAL: Mobile service quality measurement. Electron. Comm. Res. Appl. (2015), http://dx.doi.org/10.1016/j.elerap.2015.01.003

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