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Understanding Post-adoption Usage of Mobile Data Services: The Role of Supplier-side Variables

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Abstract

This study investigates factors that affect usage changes in mobile data services (MDS). First, we conducted an exploratory study based on 378 survey responses to learn about important decision factors of MDS usage. It revealed a discrepancy between the forces influencing usage increase and those of usage decrease. Based on the findings from the exploratory study and Hertzberg's two-factor theory, we postulated information quality as the motivator and system quality as the de-motivator of MDS usage. Then, we undertook a confirmative study on the respective roles of these factors in encouraging and discouraging the usage of MDS. We proposed a research model and empirically tested our hypotheses with partial least square (PLS) analysis based on 478 responses from MDS users. Information quality (as a motivator) was positively associated with MDS usage increase, but system quality (as a de-motivator) was not. Also, system quality was negatively associated with usage decrease, but information quality was not. Last, their association was partially moderated by the type of motivation for using MDS. Information quality had a stronger influence on MDS usage increase when the main motive was utilitarian rather than hedonic.

Key words: *Information Quality, System Quality, Two Factor Theory, Motivator, Hygiene Factor, Mobile Data Service*

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1. Introduction

Conventional telecommunications technologies, characterized by wires, fixed locations, and inflexibility, are rapidly giving way to mobile technologies. Numerous research reports point to the ultimate domination of wireless communication. With the increasing prevalence of advanced cell-phones, various mobile data services (MDS) are gaining in popularity as well. MDS include digital data services such as news on various topics, Internet searching, mapping and location-based information, mobile banking, and gaming that can be accessed via mobile devices over a wide geographic area. Although cellular networks as the dominant MDS infrastructure were originally introduced for voice communications, statistics indicate that data services are replacing voice service as the growth engine for telcos. For instance, SK Telecom, Korea's largest mobile service provider, reported that 24.9 percent of ARPU (average revenue per user) (2007, 3Q) came from MDS, and the share has been growing (SK Telecom, 2007a). Statistics also indicate that, although ARPU for voice service decreased 2.5 percent in 2006, MDS grew 11.2 percent from the previous year, further highlighting the growth potential of data services (SK Telecom, 2007b).

Despite the rapid ascendance of MDS as a major market for telecom service providers, the research on how individuals at different stages of MDS adoption or with different usage behaviors react to varied service-related characteristics is in its nascent stage. This is a salient issue particularly to the MDS providers who have to make large-scale investment decisions and need to best the competition by making the most out of the service infrastructure. One of the prominent issues for service providers is that, given the various types of MDS users (e.g., heavy vs. light users; increasing, plateauing vs. lapsing users), the approaches relevant to information systems that may be taken to achieve the business goal. Our research is an attempt to provide some insight. The theoretical issue of MDS as an IT service, along with its huge economic implications, warrants focused research.

MDS have unique value factors including: *ubiquity*, with real-time information flow and e-commerce transactions from any place; *reachability* and *instant connectivity* to clients and information; *convenience* and *mobility* of devices; service customization according to user locations or target area s; *personalization capability* of information services according to user profiles; and *timeliness* in service rendering (Lee and Benbasat, 2003; Pedersen, 2005; Rao and Troshani, 2007). Hong and Tam (2006) characterized MDS in terms of exclusive access to a platform, ubiquitous services and access, and rich utilitarian and hedonic functions. Given that most of the studies of IS adoption and usage have been conducted in the organizational context, their findings may not necessarily be applicable to MDS (Hong and Tam, 2006; Rao and Troshani, 2007). Above all, such value features as ubiquity, reachability, mobility and convenience, and customization are not perceived to be key elements of a corporate IS in conducting business tasks. Furthermore, unlike an organizational IS, which supports business tasks (ex. operation and decision support), current usage of MDS remains largely personal, although its role as an integral part of the corporate IT infrastructure will surely grow.

With corporate mandated MDS usage (ex. access to corporate databases and CRM systems) virtually non-existent in Korea at the time of survey, the study context of our research is limited only to personal usage of MDS. In general, studies indicate that people use MDS mainly for two reasons (motivations): hedonic and utilitarian (Hong and Tam, 2006; Rao and Troshani, 2007). An exploratory data analysis indicated that, contrary to the findings of many previous studies on information systems, factors that significantly affect the increase and decrease of MDS usage may be distinctly separated. Users mainly increased MDS usage when they perceived strength in the information quality aspects of the service, and they reduced MDS usage when they perceived weakness in its system quality dimensions.

We found the conceptual basis of the uni-directional influences from the two-factor theory pioneered by Herzberg et al. (1959). Grounded on this theory, we conducted a confirmative study to further examine the uni-directionality of the factors identified in MDS usage. The confirmative research considerably deviates from extant studies of IT usage that presume the bi-directionality of explanatory variables in influencing the level of dependent variables (i.e., IS usage). The research goal is,

therefore, to examine if the change (increase vs. decrease) in MDS usage by an individual is explained by two different groups of variables pertaining to information quality and system quality. More specifically, we investigate the following questions: (1) Does information quality play a bigger role than system quality in increasing MDS usage?; (2) Does system quality play a larger role than information quality in decreasing MDS usage?; and (3) Does the type of user motivation moderate the effect that information and system quality have on MDS usage? To answer these research questions, we determined indicator variables of information quality and system quality in the context of MDS and studied their significance through empirical survey and data analysis. We discuss important theoretical and practical implications of the findings.

2. Previous MDS Research

With the increasing prevalence of mobile services, a number of related studies have been conducted. Above all, MDS offer a unique value to consumers by allowing for time and place independence (Lee and Benbasat, 2003; Mallat et al., 2004); increased control over their affairs (Jarvenpaa et al., 2003); convenience, ubiquity, flexibility, and contextuality (Lee and Benbasat, 2003; Looney et al., 2004; Venkatesh et al., 2003); enhancing a specific domain quality of life (QoL), contribution to overall QoL (Choi et al., 2007). Anckar and D'Incau (2002) suggest the potential customer value of the MDS in terms of five value contexts: time-sensitivity (i.e., urgency), spontaneity (as opposed to pre-planned), entertainment needs (i.e., time-filler), efficiency needs (i.e., productivity), and mobility related (i.e., location-based or localization services). Advanced mobile technologies enable tracking and monitoring, content provision, controlling, and a host of other services with unprecedented levels of customization (Barnes, 2003). There are, however, challenges associated with MDS as well. Constraints in terms of user interface (i.e., small screen and keypad) and content design, and functional limitations (i.e., bandwidth, connection stability, and vulnerability in information security) are among them (Cyr et al., 2006; Jarvenpaa et al., 2003; Lee and Benbasat, 2003; Venkatesh et al., 2003).

Given the opportunities and challenges of MDS, a review of existing studies reveals two distinctive patterns. First, most research attention has been placed on examining the role of personal attributes on MDS adoption. In fact, a number of personal variables have been used to explain the intention to adopt MDS. Among them are individual disposition, self-control, subjective norm, self-efficacy, social influence, privacy, and perceived value (i.e., economic, emotional, and social) to name a few (Kim et al., 2007; Lim, 2006; Pedersen, 2005; Rao and Troshani, 2007; Turel et al., 2006). In addition, external variables can be largely divided into service-related characteristics and personality attributes (Kleijnen et al., 2004). Service-related characteristics represent supply-side (i.e., service provider-related) elements, and personality attributes are demand-side (i.e., service user-related) traits (Pedersen, 2005). Nysveen et al. (2005) further classified the demand-side variables into motivational influences, attitudinal influences, normative pressure, and perceived control. That the focus of most studies has been on the role of individual attributes may be natural to a certain degree because of the rather personal nature of MDS usage, less bound by organizational forces. However, investigating the implications of supplier-side elements is important in order to have a balanced view of the dynamism of MDS usage.

Second, most MDS-related studies employ initial adoption or the adoption intention as the dependent variable, grounded on such well known theories as TAM (technology acceptance model), TRA (theory of reasoned action), TPB (theory of planned behavior), and Roger's adoption theory (Kleijnen et al., 2004; Pagani, 2004; Pedersen, 2005). By contrast, little research has been conducted on changes in MDS usage during the post-adoption stage. That an independent variable affects the adoption of MDS doesn't necessarily mean it has a significant bearing on post-adoption usage. Factors that influence the post-adoption usage of a service rather than the adoption itself may better explain MDS usage (Nysveen et al., 2005; Pedersen, 2005). In fact, even when the domestication research is counted, little work has been undertaken on the subject of changes in MDS usage. A few studies have approached MDS research from the perspective of client loyalty. For this, such concepts as repurchase likelihood, general loyalty, and price tolerance are utilized as dependent variables (Cyr et al., 2006; Lim, 2006; Turel et al., 2006). The loyalty concept may be somewhat reflective of MDS

usage. However, loyalty, defined as a client's intention to stick to existing services, does not imply changes in MDS usage (increase, decrease, or no change). In sum, the literature review reveals that there is an absence of research focusing on dynamics associated with the post-adoption usage of MDS.

3. An exploratory study

We conducted an exploratory study to probe the role of mostly non-personality factors on MDS usage during the post-adoption stage. For the study, we initially identified in the literature factors that could either increase or decrease MDS usage, focusing on non-personality elements (i.e., DeLone and McLean, 1992). The elements included variables of system environment (i.e., access speed and reliability, interface design), cost-related perceptions (i.e., pricing and uncertainty in usage cost), information quality (i.e., content richness and content quality), and user attributes (i.e., usage skill or self-efficacy). Except for the usage skill variable, all are supplier-side variables (Pedersen, 2005). The effect of these variables on user attitudes and behavior toward an IS has been repeatedly studied in the organizational context, and a significant level of consensus has been reached. However, the same effects may not be automatically presumed when the usage of an IT service is driven mainly by individual needs as in our study. This motivated us to conduct an exploratory study initially to identify variables that trigger changes in MDS usage.

For this, we employed graduate students as interviewers for data collection. These students went out to public places (such as theaters or parks) and asked people to answer simple questions. Those with more than one year of MDS experience were initially chosen for a short interview. The first question was whether their MDS usage had increased, decreased, or remained unchanged during the past six-month period. People who answered either "increase" or "decrease" were then asked further to select the most important reason for the change from the given list of variables. In total, 749 people were interviewed in this way, and 378 respondents reported a change in their MDS usage (191 and 187 people indicated increases and decreases, respectively), together with the most important reason that triggered the change.

Figure 1 compares the "increase" and "decrease" groups in terms of frequency and percentage distribution. As shown, cost-related issues (pricing and uncertainty in usage cost) are highly distinctive in the decrease group. They are also visible in the increase group, but, are far less influential than in the decrease group. Besides financial concerns, a significant portion of responses indicated that system quality issues, including access speed, reliability and interface design, discourage MDS usage. These variables, however, have the least influence on de-motivating MDS usage. The two most important reasons for increasing MDS usage are the richness and quality of available content, which are representative dimensions of information quality (DeLone and McLean, 1992).

Results of the exploratory analysis provide a powerful indication that forces influencing usage increase and decrease can be quite distinctive and non-overlapping. The possible discrepancy in the role of the studied variables triggered further efforts in the form of confirmative research. In order to explain the divergence theoretically, we employed the two-factor theory pioneered by Herzberg et al. (1959) to explain changes in MDS usage.

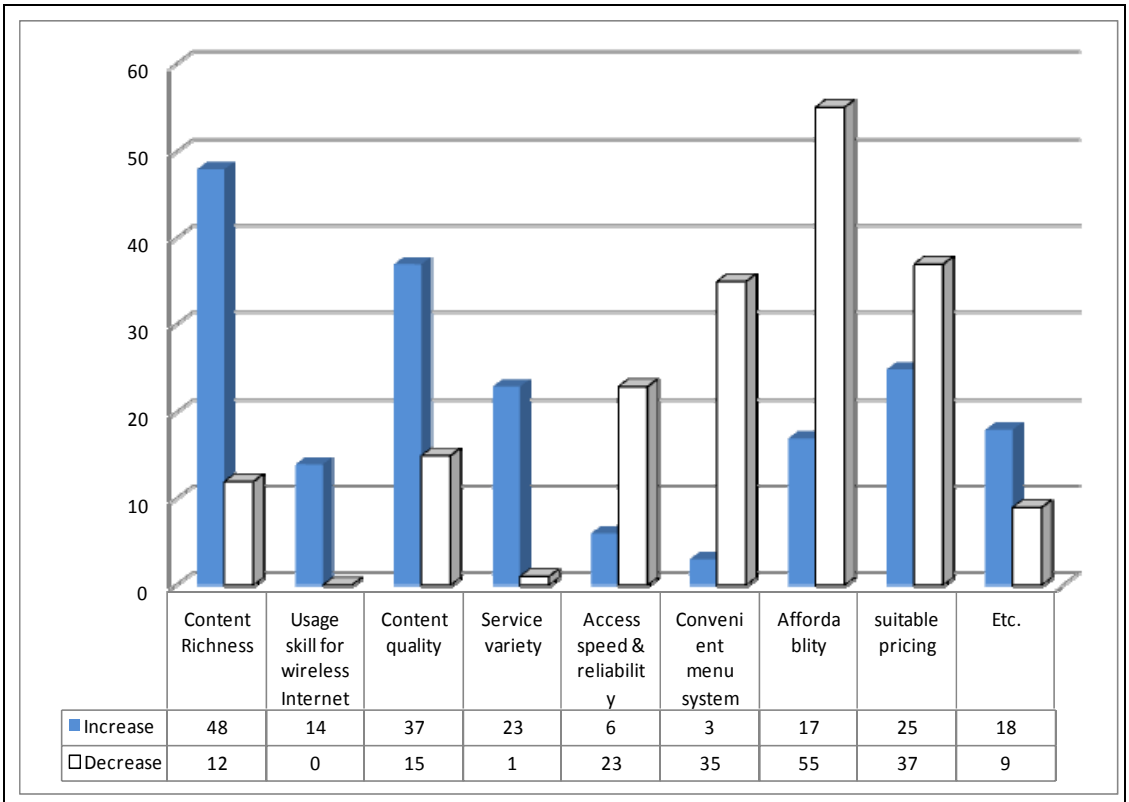


Figure 1. Influencing factors of MDS change

Note 1: The number on top of each bar represents the relative percentage. The frequency distribution of responses for the increase and decrease groups is shown at the bottom of the chart. There were 191 (usage increase) and 187 (usage decrease) responses.
Note 2: Besides the listed variables, respondents also mentioned other reasons for usage change, including service provider switching and advertisement. These responses are combined within the "Others" Category.

4. The Two-Factor Theory

The two-factor theory introduced by Herzberg et al. (1959) offers a conceptual ground to understand the disconnection between significant forces of usage increase and decrease of an IT service. It has been one of the most influential and also controversial management theories in explaining job satisfaction and motivation of organizational employees (Chowdhary and Prakash, 2005). Herzberg et al. (1959) divided organizational factors affecting the level of employee job satisfaction into motivators and de-motivators (also called "hygiene factors"). Motivators are expected to boost job satisfaction and employee performance, but their absence or insufficiency does not necessarily increase job dissatisfaction. On the other hand, the existence of de-motivators is expected to result in the dissatisfaction of employees; but their sufficiency does not necessarily lead to higher job satisfaction. The theory, therefore, argues for a weak correlation between job satisfiers and dissatisfiers.

Motivators that augment job satisfaction should offer employees a sense of accomplishment, recognition, challenge and responsibility, and prospect for advancement. Motivators are, therefore, mostly task-related, intrinsic to job content, administered by the employee, and closely related with a person's sense of internal growth (DeShields et al., 2002; Luthans, 1995). Motivators are "internally-generated drivers, not externally stimulated incentives" (Bassett-Jones and Lloyd, 2005). By contrast, de-motivators subsume non-task conditions such as financial rewards, security, firm rules and policy, management and supervision, and organizational environment (Herzberg, 1959; Luthans, 1995). They are largely extrinsic, environmental, and controlled by someone other than the employee herself/himself (DeShields et al., 2002). Their perceived strength does not necessarily fortify job

satisfaction, but their weakness is said to discourage employees. For instance, the motivational effect of financial rewards is expected to be weak once employees pass a certain threshold level; but, the paucity of financial rewards can significantly de-motivate people (Bassett-Jones and Lloyd, 2005). Herzberg et al. (1959) argued that, to motivate employees, human resources managers should be focused on enhancing internal rewards rather than on removing external sources of dissatisfaction.

Despite much criticism and controversy regarding its validity, the two-factor theory has staying power because of conceptual clarity (Bassett-Jones and Lloyd, 2005). Also, although the theory was initially introduced for the explanation of job-related satisfaction vs. dissatisfaction, it was brought into the domain of satisfaction with products and services. For instance, Chowdhary and Prakash (2005) discussed motivators and de-motivators in terms of *vantage* factors that differentiate services, and *qualifying* factors that clients take for granted in subscribing to a service. They argued that the dimensions of service/product quality (i.e., accuracy, reliability, responsiveness, efficiency, security and assurance) could be divided into motivators and de-motivators. Based on the two-factor theory, Swan and Combs (1976) derived the concept of *instrumental* variables, representing the performance of a product *per se*, and *expressive* variables embodying the psychological performance of the product. In addition, the association between service quality factors and consumer satisfaction/dissatisfaction is shown to be contingent on service types (i.e., labor or capital intensity), type of industry, and personal characteristics (i.e., demographics and psychographics) (Chowdhary and Prakash, 2005).

In addition to the two-factor theory, IS success models proposed by various studies (i.e., Bharati and Chaudhury, 2006; Chin et al., 1995; DeLone and McLean, 1992; Davis 1989; Rai et al., 2002; Seddon, 1997) underscore the importance of *system quality* and *information quality* in furthering system *usage* and *user satisfaction*, and subsequently *personal and organizational performance* (i.e., reduction in operational cost). Variables of system quality (i.e., flexibility, portability, ease of use, reliability, and integration) reflect the technical elements of an IS necessary to deliver target content successfully. In addition, dimensions of information quality (i.e., completeness, relevance, accuracy, timeliness, and consistency) represent the characteristics of information at the semantic level (DeLone and McLean, 1992). The ultimate goal of using an IS is to serve people through the provision of information they need. This enables us to conjecture that information quality is an *intrinsic* goal of system usage. Taking it one step further, system quality forms an *environment* instrumental in satisfying user information needs. It is, therefore, expected to set *extrinsic* conditions of successful MDS usage. The two-factor theory offers a conceptual basis regarding their discrepant roles in changing MDS usage.

5. Study Variables and Research Model

As the results of our exploratory study and extant IT research indicate, the usage of MDS is contingent on many technological, business strategic, economic, and behavioral elements. Economic concerns are especially expected to have a high impact on MDS usage, as service charges are typically usage dependent, having direct financial implications for clients (Lim, 2006; Turel et al., 2006). The focus of our confirmative research is, however, limited to IT factors comparing the effects of information quality and system quality in furthering or lessening MDS usage. They represent two key dimensions, along with user attitudes toward an IS, that affect the satisfaction of system users (Turel et al., 2006). Unlike demand-side user attitudes, information quality and system quality are representative supply-side traits with important bearings on service quality (Chowdhary and Prakash, 2005).

5.1. Information Quality

The information quality variable represents the quality of information content produced and offered through MDS. The term is often used synonymously with data quality, although information may be generally regarded as a broader concept in its definitional scope than data. Information quality is known to affect usage intention and user behavior (Bharati and Chaudhury, 2006; Davis et al., 1989) and, therefore, has been an important criterion in judging the quality and subsequent success of an IT service. Information quality itself is a multi-dimensional concept, for which extant studies have introduced a number of indicator variables. Among them are accuracy, precision, relevance, currency,

completeness, sufficiency, comparability, timeliness, reliability, understandability, and scope (Bailey and Pearson, 1983; Bharati and Chaudhury, 2006; DeLone and McLean, 1992; Miller, 1996; Redman, 1996; Strong et al., 1997; Zmud, 1978). The requirements of information quality were identified mainly in the context of organizational IS and, therefore, may not be equally important for individual mobile services. We, therefore, determined the significant information variables, based on a review of existing literature, that are oriented toward personalized services. For example, in the study of web-based services, McKinney et al. (2003) categorized key dimensions of information quality in terms of *relevance*, *timeliness*, *reliability*, and *scope*. These variables are conceptually discriminant from each other and at the same time semantically inclusive to cover the construct space. Thus, we adopted them in our study. Their operational definitions and literature sources are indicated in Table 1.

Table 1. Indicator variables of information quality

Dimensions	Definition	Sources
Relevance	Adequacy, preciseness, and significance of available information	Bailey and Pearson (1983) Davis et al. (1989) Seddon (1997) Wilkerson et al. (1997)
Timeliness	Currency of available information	Ables et al. (1997) Bailey and Pearson (1983) Wilkerson et al. (1997) Zmud (1978)
Reliability	Accuracy and consistency/stability of available Information	Bailey and Pearson (1983) Doll and Torkzadeh (1988) King and Epstein (1983) Wilkerson et al. (1997)
Scope	Completeness and exhaustiveness of available information	Bailey and Pearson (1983) Doll and Torkzadeh (1988) King and Epstein (1983) Wilkerson et al. (1997) Zmud (1978)

5.2. System quality

System quality is a person's general perception of MDS in terms of software and hardware performan ce (Bharati and Chaudhury, 2006) and can be a second-order construct reflected by various system f eatures. The role of system quality in the success of an IT service has been investigated (Barki and H artwick, 1989; Bharati and Chaudhury, 2006). Existing literature on information systems introduces a number of variables relevant to the success dimension; their choice within a study is more context-dependent (i.e., web). Among the manifest variables are access convenience, flexibility, integration, response time, sophistication, reliability, accessibility, stability, system speed, usability, ease of use, n avigation, and network speed (Bharati and Chaudhury, 2006; DeLone and McLean, 1992; Kim and Ki m, 2002; Liao and Cheung, 2001; Wilkerson et al., 1997).

Not all the variables are equally important when it comes to individual usage of MDS. The system environment of MDS includes mobile telecommunication channels, operational support systems, terminals such as cellular phones, and user applications and interface. The perceived system quality is, therefore, expected to be dependent on the overall integrity of technical architectures of MDS in nourishing user experiences. To determine system variables particularly germane to the research, we reviewed current studies conducted on personalized services. For instance, McKinney et al. (2003) suggested that access, usability, navigation, and interactivity are key dimensions of system quality for web services. From the review of existing studies, we deemed *access, usability*, and *navigation* to be conceptually discriminant from each other and also highly salient traits in facilitating the user experience of ubiquity, flexibility, and contextuality, and in overcoming technical limitations of MDS such as the small screen size and keypad (Jarvenpaa *et al*., 2003; Lee & Benbasat, 2003). Their operational definitions and literature sources are summarized in Table 2.

Table 2. Indicator variables of system quality		
Dimensions	**Definition**	**Sources**
Access	Degree of accessibility, responsiveness, stability, and availability of mobile data services	Bailey and Pearson (1983) Novak et al. (2000) Schubert and Selz (1999) Wilkerson et al. (1997)
Usability	The design aspect of user screens in terms of ease of use, visual attractiveness, user friendliness, and convenience in delivering mobile data services	Abels et al. (1997) Bailey and Pearson (1983) Davis (1989) Doll and Torkzadeh (1988) Wilkerson et al. (1997) Zmud (1978)
Navigation	The effectiveness in navigating between screens of mobile data services	Abels et al. (1997) Wilkerson et al. (1997)

5.3. Motivation for MDS usage

Existing studies have implied the importance of motives in determining the degree of MDS usage (i.e., Katz and Aspden, 1997). Pavlou and Stewart (2000) suggested three key motives for using MDS: information access, entertainment, and social relationships. Several other studies classified the main motives in terms of utilitarian goals, i.e., pursuing specific information, and hedonic goals that take a more leisurely form (Nysveen et al., 2005; Rao and Troshani, 2007). MDS can satisfy clients' information needs through their distinctive strengths in service ubiquity, reachability, localization, pers onalization, and timeliness (Anckar and D'Incau, 2002; Lee and Benbasat, 2003). Through information access, for example, MDS users attempt to find value-added and up-to-date information in an expedited manner. Location-specific information services, personalized information services, an d global connectivity offer users the sense of utility and control over tasks at hand. Studies also indicate that hedonic functions such as online gaming can be a major motive for the adoption of MDS (Nysveen et al., 2005; Van der Heijden, 2004). In our study, therefore, we adopt utilitarian and hedonic benefits as two key motives for MDS usage.

6. Research Model

A research model is shown in Figure 2 where information quality and system quality, two latent variables manifested by the selected first-order variables, directly affect the dependent variable: change in MDS usage. Grounded on the two-factor theory, information quality is considered a satisfier, and system quality a dissatisfier. User motivation for adopting MDS is positioned as a variable that moderates the association between the two latent variables and the dependent variable. In sum, the goal of this research is to understand how two variables change the usage of MDS and how the motivation type moderates the association.

In conducting the research based on the two-factor theory, we assure that most people are in a relatively steady state of MDS usage, as it is largely determined by their unique needs and opportunities, and the steady state may reside in the vicinity of the mid-point between satisfaction and dissatisfaction. Another assumption is that there can be substantial variations in the steady level of usage even among people who are generally satisfied or generally dissatisfied with MDS, again because of reasons germane to each MDS user. Starting with these two assumptions, we expect each of the satisfier and dissatisfier variables to play the role of changing the usage state either positively or negatively.

With these two assumptions, having *actual usage* of MDS as the dependent variable like many past adoption or post-adoption studies cannot serve our research objectives for two reasons. Above all, our research goal is to understand changes in a person's MDS usage regardless of his/her absolute usage level. Here, using actual usage as a dependent variable defeats the study purpose because it presumes the similitude of MDS usage when people's perceptions of system and information quality

coincide. Second, using actual usage assumes the uni-dimensional linear relationship between the independent variables and the dependent variable, contradicting the theoretical position of this research.

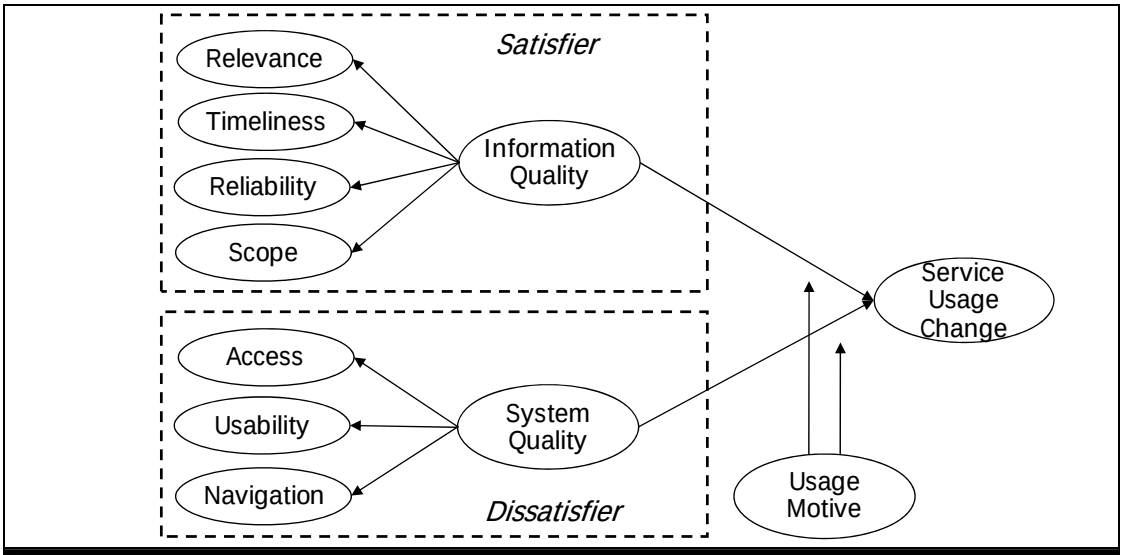


Figure 2. Research model

6.1. Hypotheses

In line with the view of the two-factor theory, we develop hypotheses separately for the two opposite behaviors (increase vs. decrease) in MDS usage.

6.2. Increase in MDS Usage

Improved information quality is expected to enhance users' positive experience of MDS. As information access is a primary reason for using an IT service for many people, information quality becomes intrinsic in satisfying that goal. From the perspective of the theory of Herzberg et al. (1959), therefore, information quality constitutes a motivator and internal driver of MDS usage, directly associated with enhancing user tasks. It is expected that a higher level of information quality leads to greater satisfaction with MDS, resulting in increased use. From this perspective, information quality becomes more of an expressive and intangible rather than instrumental and tangible force (Chowdhary and Prakash, 2005; Swan and Combs, 1976). Information quality may be closely associated with the perceived usefulness of a service that directly benefits a user one way or another and enhances task experience. Naturally, information quality reflects perceived service value, a function of customer needs, among existing users. As implied by Chowdhary and Prakash (2005), information quality becomes a vantage factor that differentiates services rather than a qualifying factor that clients take for granted in subscribing to a service.

System quality sets the extrinsic (rather than intrinsic) conditions of MDS necessary for clients to take advantage of available information. It forms an environment and a qualifying platform necessary to undertake intended tasks (i.e., information acquisition) and optimize experience. It is a contextual dimension rather than a content dimension. From the theoretical perspective of Swan and Combs (1976), system quality reflects the instrumental aspect of MDS, and its performance below the thresh old expectation level could lead to dissatisfaction with MDS. However, the role of system quality in mo tivating service usage may be limited; users become less mindful about system performance as long as their expectation level (conscious or not) is satisfied by the service provider. This means that syste m quality is a necessary, but not sufficient condition (Chowdhary and Prakash, 2005). Further enhanc ement of system quality beyond an acceptable level may not add more value to MDS users and may not lead to higher usage of MDS unless they find useful or beneficial values from available content (D

avis, 1993). From the discussion so far, we hypothesize that:

> *H1: Perceived information quality is more influential than perceived system quality in increasing MDS usage.*

The concept of MDS usage largely presumes voluntary efforts and participation by an individual subscriber. This participation is expected to be strengthened when a person understands the goal of system usage and when MDS effectively realizes that goal. As such, existing studies highlight the importance of motivating forces in increasing service participation (Rodgers and Thorson, 2000; Katz and Aspden, 1997; Pavlou and Stewart, 2000). Examining motivation further, we expect a synergistic effect when there is better alignment between the perceived characteristics (information quality and system quality) of MDS and an individual's main motivation for MDS usage. This leads to the reasoning that a user's motivation to acquire information may be influential in re-defining the relationship between information quality and MDS usage.

Meanwhile, from the perspective of the two-factor theory (Herzberg et al., 1959), variables of system quality are more extrinsic and environmental in improving user satisfaction of a service. System quality is a requirement that, once its performance is up to the expectation level, clients may take for granted in utilizing a service, and, therefore, the effect of system quality on usage increase may be insignificant. As system quality is expected to become a qualifying rather than a vantage factor (Chowdhary and Prakash, 2005), the effect of the motivation type (utilitarian vs. hedonic) in moderating the association between system quality and usage increase may not be substantiated. Therefore, we hypothesize that:

> *H2: The moderating effect of motivation types is greater on the information quality-MDS usage link than on the system quality-MDS usage link. The influence of information quality in increasing MDS usage is strengthened more when the main motive is information acquisition than when it is hedonic.*

6.3. Decrease in MDS usage

Studies indicate that system quality positively affects user satisfaction and system usage (DeLone and McLean, 1992; Seddon, 1997). From the studies, we observe two different association relationships defined between system quality and system usage. In the first, some studies postulate a direct and positive association between system quality and system usage (i.e., DeLone and McLean, 1992). The second group hypothesizes that system quality influences user satisfaction, which in turn increases system usage (i.e., Seddon, 1997). The majority of these studies concur that the level of system quality is correlated with system usage. Again, it is important to remember that these studies are mostly conducted in the organizational context in which IS usage is significantly affected by non-individual, collective forces (i.e., organizational cultures, goals and objectives, management support).

The theory of Herzberg et al. (1959), on the other hand, implies that, when MDS usage is significantly influenced by individual-level attributes, system quality becomes a significant de-motivator because of its supportive, contextual, and extrinsic (rather than native, content, and intrinsic) role in achieving intended goals. When system quality begins to drop below an acceptable level, MDS users may begin to notice the effect of its deterioration in undertaking intended tasks, increasing their dissatisfaction with the service. In a similar vein, according to Swan and Combs' (1976) modified two-factor theory, *instrumental* variables determine the performance of a product, and *expressive* ones set the psychological tone of the product. According to them, customer satisfaction with a product tends to improve when its expressive values are higher, but low values do not necessarily translate into increased dissatisfaction with the product. However, dissatisfaction with the product increases when instrumental values fall below the psychological or cognitive expectation level. System quality is conceptually similar to the *instrumental* or *qualifying* factors (Chowdhary and Prakash, 2005; Swan and Combs, 1976) in which a certain degree of system quality is essential to sustain MDS usage by clients. Inadequate performance of a system limits users' ability to exploit available information, hampering their sense of fulfillment. Accordingly, inadequate system quality decreases customers'

motivation for service usage, especially when they have a narrow tolerance for system performance. The effect of system quality is, therefore, expected to be more salient in decreasing MDS usage than in increasing it. In addition, poorer information quality might contribute to a decline in MDS usage. This, however, may not be as obvious as the negative effect of system quality because of the essential nature of information (or content) acquisition in MDS. Therefore, we hypothesize that:

H3: Perceived system quality is more influential than perceived information quality in decreasing the usage of MDS.

7. Survey

7.1. Design

For the empirical study, we designed a survey questionnaire. It was composed of questions on (1) the usage of MDS (i.e., service provider, monthly spending, type of applications, usage frequency, and usage motivation); (2) information quality; (3) system quality; (4) usage changes during the last six-month period; and (5) user demographics. The survey was developed in part by modifying validated items from previous studies (those of information quality and system quality) and by converting definitions into question items (those of usage increase and usage decrease) to fit the context of MDS. For the survey items of information quality and system quality, we relied much on Mckinney et al. (2002), who identified relevant variables of information quality and system quality in the context of web access. The variables in Mckinney et al. (2002) were believed to be highly relevant because of the resemblance between web access and MDS as personal-level experiences. We developed four question items for four constructs (timeliness, access, usage increase, and usage decrease) to increase the number of indicators. At the beginning of the survey, we included a definition of MDS along with the list of popular services available for personal usage. It included news and daily information, stock market, mobile banking, Internet search, and navigation service as examples of information services. Meanwhile, coloring music (for ring-back tone), bell sounds, games, drama, and other live shows were listed as examples of hedonic usage.

We arranged a discussion session in which graduate students (both Masters and Ph.D. levels) identified semantic ambiguities in the survey items, and we made necessary corrections. Additionally, we conducted a pilot test to further improve the reliability of the questionnaire. All responses were based on the 7-point Likert scale in which 1 = "not agree at all," 4 = "neutral," and 7 = "absolutely agree." Table 3 summarizes the number of survey items (see Appendix 1 for survey questions) used for the studied variables and their derived sources.

Table 3. Summary of the survey questionnaire

Variables			**# of items**	**Sources**
Independent Variable	Information Quality	Relevance	3	McKinney et al. (2002) One "timeliness" item was developed by authors
		Timeliness	3	
		Reliability	4	
		Scope	3	
	System Quality	Access	4	McKinney et al. (2002) One "access" item was developed by authors
		Usability	4	
		Navigation	3	
Dependent Variable	Service Usage Change	Usage increase	3	Seddon (1997) One item for each category was developed by authors
		Usage decrease	3	

For the survey, we employed a professional survey firm (www.wsurvey.net) that maintains its own online survey panel. The survey was posted online and emails soliciting survey participation were

sent to 2,500 people randomly selected from the panel group of 20,000 maintained by the firm. Teens at least 17 years old (high school age) were included in the sampling frame to maintain the accuracy and integrity of responses. Also, only those people who had been using MDS for more than a year at the time of survey, and whose MDS usage had changed during the past six-month period, were targeted for data gathering. For the necessary screening, respondents were first asked two questions: "How long have you used mobile data services?" and "Have you experienced an MDS usage change (increase or decrease) in the last six months?" Then, only respondents who met the qualifications were allowed to proceed with the survey. In total, 485 responses were returned, 478 of which were used for data analysis after seven incomplete ones were dropped.

Table 4. Demographics of survey respondents

Demographics		Frequency Total: 478	%	Demographics		Frequency Total: 478	%
Gender	Male	238	49.8	Average spending on MDS (per month)	~ $5	159	33.3
	Female	240	50.2		$5~ LT $10	136	28.5
Age	17~19	44	9.2		$10~ LT $15	83	17.3
	20~29	252	52.7		$15~ LT $20	35	7.2
	30~39	158	33.1		$20~ LT $25	20	4.2
	40~49	22	4.6		$25~ LT $30	17	3.6
	50 ~	2	0.4		$30~	28	5.9
Occupa-Tion	Student	158	33.1	Changes in service usage	Increased	310	64.9
	Office worker	153	32.0		Decreased	168	35.1
	Professional	68	14.3	Motivation for service usage	Information/data	138	28.9
					Entertainment	340	71.1
	Technician	37	7.7	Average number of monthly usage sessions	~ $30	239	50.0
					$30 ~ LT $40	135	28.2
					$40 ~ LT $50	55	11.5
	Homemaker	38	7.9		$50 ~ LT $60	24	5.0
					$60 ~ LT $70	2	0.4
	Other	24	5.0		$70 ~ LT $80	7	1.5
					$80 ~	16	3.4

Table 5. Descriptive Statistics of first order variables

2nd-Order Variables	1st-Order Variables	Increase (N=310)		Decrease (N=168)	
		Mean	Stdev	Mean	Stdev
Information Quality	Relevance	4.762	1.287	4.494	1.177
	Timeliness	5.054	1.365	4.643	1.340
	Reliability	4.621	1.317	4.277	1.165
	Scope	4.617	1.357	4.353	1.295
System Quality	Access	3.903	1.500	3.332	1.378
	Usability	4.183	1.360	3.729	1.244
	Navigation	3.782	1.533	3.238	1.324
	Usage	4.859	1.025	4.750	1.430

7.2. Demographics & Descriptive Statistics

Table 4 summarizes the demographics information of the survey respondents. Responses were balanced in terms of gender distribution, with 49.8percent males and 50.2percent females. The age

distribution indicated that most respondents were in their 20s (52.7percent) and 30s (33.1percent), revealing these as the two most active user groups of MDS. Also, the occupational distribution showed that 54percent of people surveyed (excluding the "others" category) were participating in economic activities, while 41percent (i.e., homemakers and students) were not. Among those surveyed, 64.9percent and 35.1percent reported increases and decreases in their usage of MDS, respectively. This reflects the upward trend of Internet access via the faster cellular phone infrastructure. We also learned that the main motivation for using MDS was not information access (28.9percent), but entertainment (71.1percent). The dominance of hedonic interests in MDS usage may be due to the fact that people in their 20s and 30s occupied the lion's share of the user group.

Table 5 summarizes descriptive statistics of the study variables.

8. Analysis Results

8.1. Tests of Validities and Common Method Bias

We used PLS to validate the integrity of the research model and the significance of the proposed hypotheses. As a structural modeling technique, PLS has been used to examine social and organizational phenomena associated with information systems (Barclay et al., 1995). We can analyze convergent validity by comparing factor loadings and cross-loadings (Wixom and Watson, 2001), as summarized in Appendix 2. When we tested convergent validity separately for the two groups (usage increase and usage decrease groups), the result was almost identical to that of the combined data, confirming a high degree of convergence among indicator items of the studied factors (both first-order and second-order).

In PLS, testing the reliability of a factor can be done via the CSRI (Composite Reliability Index), similar to Cronbach's alpha. If CSRI is greater than 0.7, it is estimated that the internal consistency of the indicator items has been achieved (Fornell and Larcker, 1981). Appendix 3 shows that all constructs have values greater than 0.7 for both CSRIs and Cronbach's alphas, confirming their reliability. To examine the discriminant validity between constructs, we present values of squared AVE (Average Variance Extracted) in Appendix 4. In both the first- and second-order factors, they are greater than the squared values of the correlation coefficients, indicating appropriate discrimination between the studied variables.

Despite the validity tests, the correlations between usability (US) and navigation (NV) variables are over .70 for both groups. While lower than the associated squared AVEs, they are still high enough to cause concern with multicollinearity since PLS is based on regression. In this study, however, this is less of an issue because high correlations are assumed among the first-order variables of a reflective second-order construct. Nonetheless, we conducted a test on common method bias (CMB) to examine the possibility of systematic measurement errors.

For the CMB test, we adopted the procedure suggested by Pavlou et al.'s (2007). First, we undertook the principal components factor analysis to examine the existence of a factor that explains the majority of common variance. If the factor exists, this becomes an indication of CMB. The test showed that the amount of variance explained by identified factors was relatively evenly distributed with average = 10.41percent (increase group) and 10.51percent (decrease group) and standard deviation = 2.26 percent (increase group) and 1.94 percent (decrease group). Second, we conducted a partial correlation analysis in which the highest factor identified was added as a control variable to examine its effect on the dependent variable. The result reveals a very weak contribution of the control variable in both usage increase and usage decrease models. With the control variable, R^2 was improved by 0.005 (from .175 to 0.180) and 0.004 (from 0.050 to 0.054), respectively. Third, generally CMB exists when correlation coefficients are 0.9 or above (Pavlou et al., 2007) and the highest coefficient in the correlation matrix was 0.74. After the tests, we concluded that there is little risk of CMB.

8.2. Structural Equation Modeling

We conducted PLS-based structural modeling separately on the usage increase (Figure 3) and decrease (Figure 5) groups. With the significance of the measurement models confirmed (Appendix 2), Figures 3 through 6 summarize the path coefficients of the structural models only. We divided the survey responses into the two (increase and decrease) groups based on item 4a in Appendix 1 regarding usage change during the last six-month period. In the usage increase group, information quality positively affected the usage increase of MDS (t=5.953), but the effect of system quality on the dependent variable was negligible (supporting H1). R-square revealed that 17.5percent of variations in usage growth can be explained by information quality, showing substantial explanatory power of the latent variable.

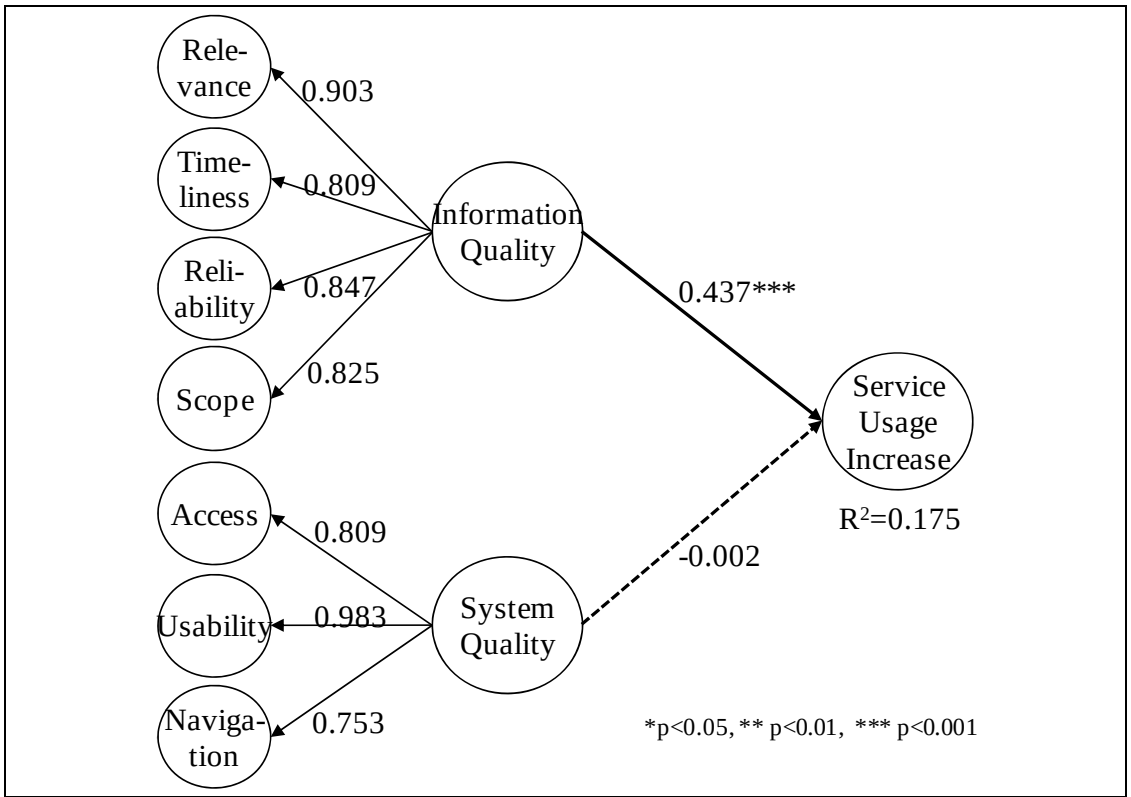
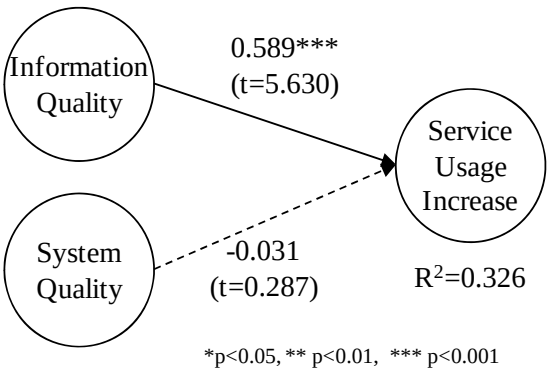
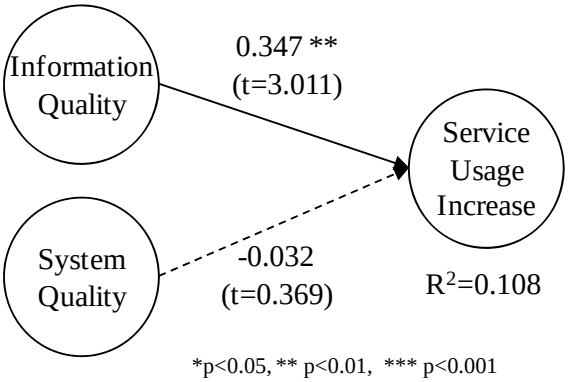


Figure 3. Path coefficients (usage increase group) (N=310)

We examine the effect of usage motivation in moderating the association between the independent and dependent variables. To measure the moderating effect, we divided responses of the increase group into two sub-groups according to the motivation type (information acquisition or hedonic engagement). Then, we separately estimated the effect of the independent variables on usage increase for each motivation group, which is a common practice in moderator research (Truel et al., 2006). Tests indicated that the effect of information quality on usage increase was partially moderated by the motivation factor. When the motivation for MDS usage was mainly in information acquisition, the path coefficient increased from 0.437 to 0.589, and the R-square value jumped from 0.175 to 0.326 (Figures 3 and 4a). The results suggest that the motive for information acquisition strengthened the association between information quality and usage increase. However, when the usage motive was mainly hedonic, the association between information quality and usage increase lowered from 0.437 to 0.347 (Figures 3 and 4b). The R-square value also decreased from 0.175 to 0.108, indicating that the explanatory power of information quality on usage increase weakened when the usage was mainly entertainment-driven. Meanwhile, Figures 3 and 4 reveal that the effect of system quality on usage increase remains unchanged regardless of the motivation type.



4a. Information motivation(N=100)



4b. Entertainment motivation(N=210)

Figure 4. Moderating effects of usage motivation (usage increase group)

We compared the path coefficients of two sub-models in Figure 4 based on the t-test statistic shown below (Teo et al., 2003; Keil et al., 2000) to formally validate the difference in moderating effects, and, the results are summarized in Table 6.

$$t = \frac{Path_{sample\,1} - Path_{sample\,2}}{\sqrt{\frac{(m-1)}{(m+n-2)} \times SE^2_{sample1} + \frac{(m-1)}{(m+n-2)} \times SE^2_{sample2}} \times \frac{1}{\sqrt{\frac{1}{m} + \frac{1}{n}}}} \quad (1)$$

Table 6. T-test comparison of path-coefficients (Increase group)

Path	Motivation type		t-Value
	Information	Entertainment	
Info. Quality -> Usage	0.589	0.347	19.819***
Sys. Quality -> Usage	-0.031	-0.032	0.086

It re-confirms that the effect of information quality on usage increase is stronger when the main motivation of MDS is information access rather than hedonic. However, the effect of system quality on usage increase was not differentiated by the motivation type, supporting H2.

In the usage decrease group, the system quality variable was negatively associated with usage decrease at t=2.540 (Figure 5). This result confirms that the lower the perceived quality of the MDS system in terms of its accessibility, usability, and navigation, the larger the reduction in MDS usage. However, the effect of information quality on the dependent variable was insignificant (supporting H3). The R-square value, 0.050, indicates that the decrease group was less sensitive to the change in the antecedent variables than the increase group was. This seems to imply that, overall, people react more to changes in information quality than to changes in system quality in terms of their MDS usage behavior. Caution must be exercised in interpreting this request, which may be partially influenced by the fact that there is more variation in information quality than in system quality in the sample.

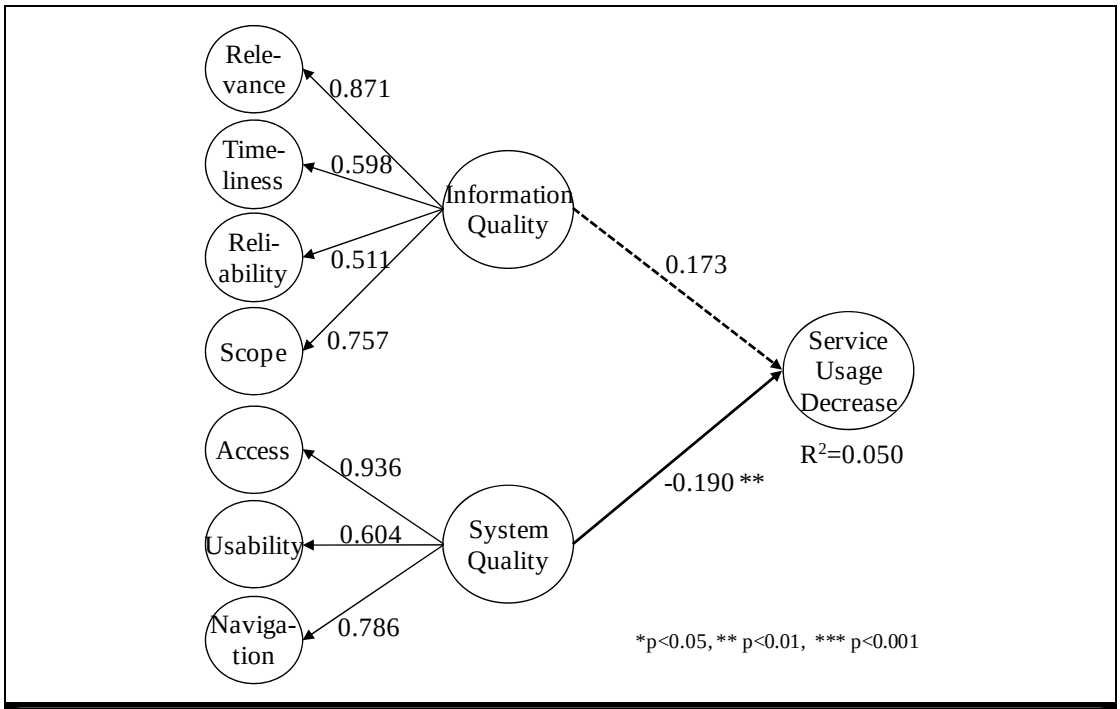


Figure 5. Path coefficients (usage decrease group) (N=168)

9. Discussion

In order to add to the research on the influencing forces of MDS usage at the post-adoption stage, we conducted a two-stage study utilizing information from both exploratory and confirmative studies. Based on the results of the exploratory study, we attempted to examine the uni-directional influences of information quality and system quality on the usage of MDS (either increase or decrease). Based on the two-factor theory (Herzberg et al., 1959), and its derived concepts (i.e., Chowdhary and Prakash, 2005; Swan and Combs, 1976), we developed our proposition that information quality becomes a significant satisfier (therefore, motivator) of MDS usage, and system quality constitutes a dissatisfier (therefore, de-motivator). In addition, we postulated that the main motivation of MDS usage moderates the association between the independent and dependent variables. The two-stage approach revealed that there is a considerable divergence between information quality and system quality in explaining the usage behavior of MDS subscribers.

Several findings come from the empirical research. As implied by the two-factor theory, the influencing force that increased MDS usage differed from the one that decreased MDS usage.

Enhanced information quality had a positive effect on usage increase, while inadequate system quality negatively affected MDS usage. The direct role of information quality in decreasing service usage, and of system quality in increasing it, was not significant. This confirms that information quality, manifested in the forms of relevance, timeliness, reliability, and scope of available information, is a significant satisfier of MDS and a key motivator of its increased utilization. Information quality, manifested by the selected four first-order variables, explained 17.5percent of variations in the increase of MDS usage. System quality, manifested by accessibility, usability, and navigation, is a key de-motivator whose enhancement does not increase service usage, but whose perceived weakness discourages people from continued MDS usage. The system quality construct, however, explained only 5percent of variations in the reduction of MDS usage, indicating that MDS users reacted more sensitively to changes in information quality than system quality.

We observed the effect of motivation type (information acquisition and hedonic benefits) on the usage of MDS. The positive effect of strong information quality on increasing MDS usage was further strengthened when a client's main motivation was utilitarian (i.e., information acquisition) rather than hedonic (i.e., entertainment). The positive association between information quality and usage increase, though significant, was substantially weakened when the main motive of MDS usage was hedonic. This demonstrates the important role of alignment between information acquisition (as the usage motive) and information quality in furthering MDS usage.

The study outcomes have implications for service providers in the telecom industry, especially in promoting MDS usage among existing clients. First, it may be important to profile people according to their main usage motivations so that more customized target marketing can be planned and executed to optimize a service provider's business performance. Those who use MDS chiefly for hedonic gratification are expected to have demographic characteristics different from those who use it for information acquisition. Our results show that, overall, a client's MDS usage is swayed more by changes in information quality than in system quality, and more by the motivation of information acquisition than of entertainment. Accordingly, it may be important for MDS providers to understand and profile customers in terms of main motivation, application types, usage orientation (i.e., individual vs. organizational), and behavioral patterns of MDS usage (i.e., temporal and spatial characteristics). This may translate into better strategies for customized marketing and service promotion, system development, and content delivery. For example, MDS promotional efforts can be customized to both current and prospective users according to their profiles (e.g., highlight the strengths of information quality to utilitarian users) to induce a higher usage among existing users or to improve the chance of new sign-ups. Also, to sharpen financial performance, a MDS provider may offer varying content levels (e.g., regular vs. premium) designed for the clients with a utilitarian orientation, instead of relying on the one-size-fits-all strategy in content provision.

Second, depending on the prospects for the future growth of MDS, a service provider may plan for priority-based resource allocation to strengthen either information quality or system quality as needed. For example, when there is much growth potential in a particular segment (or application) of MDS, a firm may place more resources in furthering information quality in order to increase MDS usage among existing users. On the other hand, when a segment of MDS is considered close to its maturity in the growth curve, a firm may channel more resources toward improving system quality in order to keep existing customers from defecting or decreasing service usage. From a slightly different angle, offering high-quality information may be more challenging and costly than improving system quality, because the former represents a soft infrastructure that may require a continuous flow of investments. However, when enhanced information quality results in higher subscription costs to MDS customers, it might de-motivate people who access MDS mainly for hedonic purposes.

10. Limitations

Our research has limitations in its research method. Above all, the reliability of findings partly rests on the integrity of assumptions discussed in the Research Model section and, therefore, should be interpreted with caution. In the study, there are both supportive and countering elements to the assumption that most people are generally in a steady state of MDS usage. First, the fact that the

survey data had a larger increase group (N=310) than the decrease group (N=168) may be an indication of population bias toward general increase in MDS usage. This may reflect that MDS is still in the early stages of adoption and diffusion and, therefore, may add noise to the usage increase group. Meanwhile, there are also elements that work in our favor. First, we limited the survey respondents to just people with at least one year of MDS experience and, therefore, their MDS usage should be largely stabilized unlike those at the early stage of adoption. Second, about half of those (371 out of 749) interviewed for the exploratory study indicated steady MDS usage during the six-month period.

Second, our sampling frame was limited to the panel group that self-selected to work with the survey firm. As such, they may not be completely representative of the MDS user population in their demographics and individual characteristics. Although this may not constitute a major issue that impedes the integrity of the findings, we would like to remind readers of the study context and its potential implications on interpreting the study results. Third, we would like to point out the possibility that the relatively weaker results for the system quality factor may be due to the lower variability of the MDS technology than of the information quality during the six-month period. In other words, it may take more time to improve system performance than content quality, and this discrepancy might have contributed to the differences in survey responses. Finally, the survey response based on self-perception of usage change (increase or decrease) can compromise reliability. Although difficult due to the privacy issue, obtaining longitudinal (not snapshot) data of actual usage during a certain period and coupling it with data from the self-report survey for analysis would shed more light on this subject.

11. Future Research

This work opens up many research opportunities. First of all, the research model can be further extended to incorporate mediating variables (i.e., user satisfaction) and other antecedent variables. We postulated a direct association between the explanatory variables (information and system quality) and usage change. This idea was grounded on the two-factor theory (Herzberg et al., 1959), in which information quality and system quality represented satisfier and dissatisfier variables. Many extant studies (i.e., DeLone and McLean, 1992; Seddon, 1997; Venkatesh et al., 2003; Wixom and Todd, 2005), however, presume that the level of user satisfaction triggers changes in user behavior associated with an IT service. Therefore, an extended research model with user satisfaction as a mediator variable and its subsequent empirical validation may further enhance our understanding of the dynamics related to MDS usage.

Users were asked to choose a primary motive for MDS usage (either information acquisition or hedonic benefits) in this study. In future work, a continuum (i.e., Likert scale) of motivation factors may be used instead of the current format that forces the survey respondent to choose one of two options. Ordinal data thus generated would enable us to appropriate other statistical analysis methods, resulting in a richer understanding of the dynamics associated with MDS usage.

In our results, 17.5percent and 5percent of the variation was explained by information quality for the increase group and by system quality for the decrease group. This implies the existence of other important variables that should be considered to increase the predictability of user behaviors in MDS in future research. Two types of variables should be especially relevant: economic issues and personality characteristics. Service cost is expected to be especially salient in explaining MDS usage, although its effect is not examined here; we chose instead to focus on the implications of MDS infrastructure (information and system quality) in changing user behavior. Herzberg et al.'s (1959) two-factor theory clearly implies that the financial burden has implications for MDS usage, especially in the usage decrease group. Our exploratory study verified this conjecture (Figure 1). In future studies, analyzing cost issues as part of the research model is expected to enrich our understanding of inter-factor dynamics (i.e., enhanced information quality vs. higher subscription cost) in MDS usage.

As MDS usage is mainly affected more by individual preferences than by forces prevalent within an organization (Hong and Tam, 2006; Rao and Troshani, 2007), personality elements play a critical role in explaining usage behavior. Information and system quality represent supplier-side variables,

whereas individual dispositions are demand-side attributes (Pedersen, 2005). Because there is little research on the association between personality and *post-adoption* MDS usage, further attention should be placed on understanding their connection. Current research on the adoption (or adoption intention) factors of MDS should supply initial variables of consideration. As a further extension, future studies can compare the effects of supply-side and demand-side variables in influencing MDS usage, and also investigate how their interaction effects influence user behavior.

The results of our study provoked the idea that one of the dominant assumptions about the success conditions of an IT service may have to be revisited to verify its generalizability. Most current studies of adoption and post-adoption usage of an IT service do not discriminate the directionality (i.e., increase vs. decrease) of influences studied factors have on the success or failure of an IT service. These studies presume uni-scalar influences of explanatory variables on the measured outcomes (i.e., individual and organizational performance). As our exploratory study indicates, however, the influence of studied variables might differ in enhancing or hampering the level of success (i.e., IT usage). The uni-directional strength of influences may depend on the context, such as service types, type of industry, individual characteristics, and the orientation of IT usage (organizational vs. personal) (Hong and Tam, 2006; Chowdhary and Prakash, 2005).

Given that the study focus is the personal usage of MDS rather than organizational or job related usage, future efforts can be made to understand issues of MDS usage in the context of organizational duties. With more organizations deploying business applications and system capability that allow remote access and modification of internal data via smart phones, corporate usage of MDS is expected to become prevalent. Main motives for usage changes and usage characteristics may significantly differ from those revealed in our study.

12. Conclusions

This study investigated factors that affect usage changes in mobile data services (MDS). Based on an exploratory study of 378 respondents and Herzberg's two-factor theory, we developed hypotheses in which information quality and system quality become a motivator (or satisfier) and a de-motivator (or dissatisfier) of MDS, respectively. We then undertook confirmative study in which information quality (as a motivator) was positively associated with usage increase in MDS, and system quality (as a de-motivator) was negatively associated with usage decrease. Their association was partially moderated by the type of motivation for using MDS. Overall, this demonstrates the intrinsic value of information quality in increasing MDS usage and the instrumental value of system quality in discouraging its utilization.

The empirical and theoretical contributions of our research can be summarized from three different angles. First, unlike most current MDS studies that concentrate on finding antecedents of initial mobile service adoption or adoption intention, our study focused on usage change during the post-adoption stage. Second, by examining the role of supplier-side variables, our study complements existing mobile research that has focused on demand-side variables (i.e., individual attributes) to explain service adoption (but not post-adoption usage). Third, through this study, we learned that the application of the two-factor theory (Herzberg et al., 1959) to various subjects of IT adoption and usage can result in a healthy theoretical contribution to IT research.

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Appendix 1. Key Survey Questions

Part 1. Questions on the motivation of mobile data service

What is your main motivation for using the mobile data service?
(1) information acquisition
(ex. news, stock, daily life, mobile banking, internet search, and navigation)
(2) entertainment
(ex. coloring, bell tones, games, drama & live shows)

Part 2. Question items on information quality

2a. Relevance
1. MDS information is *applicable* to my needs.
2. MDS information is *related* to my needs.
3. MDS information is *pertinent* to my needs.

2b. Timeliness
1. MDS information is *current*.
2. MDS information is *continuously updated*.
3. MDS information can be accessed in a *timely manner*.

2c. Reliability
1. MDS information is *trustworthy*.
2. MDS information is *accurate*.
3. MDS information is *credible*.
4. MDS information is *reliable* in serving my needs.

2d. Scope
1. MDS information covers a *wide range*.
2. MDS information contains a *wide variety of topics*.
3. MDS information covers *a broad scope*.

Part 3. Question items on system quality

3a. Accessibility
1. MDS is *responsive* to my request.
2. MDS *quickly loads* all the text and graphics.
3. MDS provides *good access*.
4. MDS is *stable*.

3b. Usability
1. MDS design has *a simple layout* for its contents.
2. MDS design is *easy to use*.
3. MDS design is *well organized*.
4. MDS design is *user-friendly*.

3c. Navigation
1. It is easy to go *back and forth* between pages.
2. It provides *a few clicks* to location information.
3. It is *easy to navigate*.

Part 4. Questions on usage change

4a. Change in the usage of mobile data service in the past 6 months
- a. Increased
- b. Decreased
- c. No change

4b: Usage increase group:
- a. Increase in the frequency of use
- b. Increase in hands-on hours
- c. Increase in usage cost

4c: Usage decrease group:
- a. Decrease in the frequency of use
- b. Decrease in hands-on hours
- c. Decrease in usage cost

Appendix 2. Tests of convergence validity

Convergent validity(Increase group: N=310)								
Items	RL	TL	RI	SP	AC	US	NV	UI
RL1	0.881	0.547	0.602	0.532	0.372	0.346	0.328	0.303
RL2	0.941	0.580	0.641	0.546	0.388	0.374	0.322	0.345
RL3	0.937	0.627	0.621	0.554	0.376	0.375	0.330	0.398
TL1	0.573	0.915	0.608	0.582	0.363	0.336	0.325	0.313
TL2	0.551	0.871	0.556	0.552	0.289	0.352	0.254	0.259
TL3	0.572	0.879	0.628	0.549	0.378	0.377	0.362	0.335
RI1	0.603	0.619	0.932	0.570	0.511	0.501	0.454	0.368
RI2	0.679	0.683	0.941	0.619	0.518	0.499	0.461	0.363
RI3	0.624	0.609	0.926	0.530	0.546	0.498	0.482	0.319
RI4	0.612	0.594	0.928	0.572	0.569	0.532	0.524	0.278
SP1	0.580	0.556	0.548	0.897	0.427	0.433	0.377	0.326
SP2	0.503	0.590	0.519	0.911	0.423	0.438	0.401	0.348
SP3	0.489	0.533	0.571	0.850	0.550	0.541	0.530	0.246
AC1	0.409	0.414	0.578	0.532	0.911	0.661	0.667	0.208
AC2	0.387	0.391	0.550	0.504	0.931	0.666	0.673	0.176
AC3	0.299	0.233	0.425	0.381	0.882	0.550	0.546	0.138
AC4	0.396	0.361	0.530	0.481	0.902	0.620	0.619	0.180
US1	0.326	0.339	0.504	0.473	0.663	0.903	0.676	0.184
US2	0.382	0.401	0.492	0.492	0.613	0.914	0.645	0.228
US3	0.385	0.363	0.504	0.492	0.615	0.913	0.660	0.228
US4	0.350	0.348	0.480	0.467	0.616	0.908	0.697	0.218
NV1	0.339	0.306	0.446	0.430	0.573	0.672	0.897	0.216
NV2	0.316	0.349	0.481	0.468	0.665	0.668	0.943	0.145
NV3	0.331	0.326	0.505	0.462	0.683	0.708	0.940	0.143
UI1	0.390	0.373	0.376	0.339	0.186	0.231	0.185	0.929
UI2	0.300	0.263	0.324	0.291	0.192	0.236	0.201	0.910
UI3	0.347	0.289	0.273	0.323	0.156	0.182	0.110	0.916

RL: relevance; RI: reliability; TL: timeliness; SP: scope; AC: access; US: usability; NV: navigation; UI: usage increase

Convergent validity(Decrease group: N=168)								
Items	RL	TL	RI	SP	AC	US	NV	UD
RL1	0.853	0.346	0.312	0.246	0.116	0.169	0.152	0.104
RL2	0.906	0.337	0.304	0.309	0.172	0.181	0.161	0.134
RL3	0.880	0.428	0.453	0.351	0.154	0.203	0.175	0.033
TL1	0.401	0.845	0.483	0.478	0.184	0.268	0.321	0.001
TL2	0.244	0.847	0.331	0.376	0.252	0.286	0.271	-.017
TL3	0.372	0.690	0.470	0.313	0.283	0.265	0.273	-.085
RI1	0.395	0.471	0.871	0.354	0.248	0.280	0.366	-.042
RI2	0.412	0.518	0.885	0.395	0.301	0.339	0.426	-.022
RI3	0.333	0.424	0.884	0.384	0.283	0.309	0.438	-.074
RI4	0.295	0.468	0.901	0.392	0.273	0.258	0.375	-.059
SP1	0.278	0.469	0.355	0.876	0.080	0.242	0.290	0.014
SP2	0.317	0.428	0.368	0.918	0.112	0.290	0.303	0.093
SP3	0.291	0.365	0.391	0.773	0.245	0.435	0.423	0.043
AC1	0.231	0.293	0.320	0.239	0.862	0.603	0.607	-.102
AC2	0.141	0.230	0.253	0.151	0.907	0.476	0.540	-.215
AC3	0.008	0.243	0.208	0.056	0.878	0.419	0.422	-.210
AC4	0.213	0.275	0.319	0.131	0.867	0.443	0.509	-.157
US1	0.192	0.314	0.260	0.389	0.410	0.844	0.554	0.032
US2	0.195	0.285	0.291	0.308	0.514	0.871	0.581	-.017
US3	0.146	0.292	0.301	0.282	0.504	0.910	0.637	-.045
US4	0.194	0.292	0.306	0.301	0.477	0.833	0.675	-.134
NV1	0.137	0.323	0.409	0.296	0.486	0.559	0.864	-.076
NV2	0.206	0.327	0.427	0.397	0.529	0.702	0.904	-.146
NV3	0.151	0.318	0.378	0.346	0.565	0.628	0.910	-.149
UD1	0.076	-.008	-.008	0.032	-.174	-0.041	-.114	0.927
UD2	0.120	-.018	-.025	0.089	-.198	-0.055	-.127	0.970
UD3	0.089	-.073	-.111	0.040	-.178	-0.035	-.149	0.930

RL: relevance; RI: reliability; TL: timeliness; SP: scope; AC: access; US: usability; NV: navigation; UD: usage decrease

Appendix 3. Reliability tests

CSRI, AVE and Cronhach's Alpha							
Variables		Composite Reliability		AVE		Cronbach's Alpha	
		Increase Group	Decrease Group	Increase Group	Decrease Group	Increase Group	Decrease Group
1st Ord.	RL	0.943	0.911	0.847	0.774	0.909	0.854
	TL	0.918	0.838	0.790	0.636	0.867	0.709
	RI	0.963	0.935	0.868	0.784	0.949	0.908
	SP	0.917	0.892	0.786	0.735	0.863	0.818
	AC	0.949	0.931	0.822	0.772	0.928	0.901
	US	0.950	0.922	0.826	0.748	0.930	0.887
	NV	0.948	0.922	0.859	0.797	0.918	0.872
2nd Ord.	UI/ UD	0.942	0.960	0.844	0.888	0.908	0.938
	IQ	0.914	0.778	0.728	0.480	0.875	0.865
	SQ	0.924	0.838	0.803	0.639	0.878	0.857

RL: relevance; RI: reliability; TL: timeliness; SP: scope; AC: access; US: usability; NV: navigation; UI: usage Increase; UD: usage decrease; IQ: information quality; SQ: system quality

Appendix 4. Tests of discriminant validity

Discriminant validity(Increase group: N=310)
Correlation of Latent Variables- 1st order

	RL	TL	RI	SP	AC	US	NV	UI
RL	0.920							
TL	0.636	0.889						
RI	0.675	0.672	0.932					
SP	0.591	0.632	0.615	0.887				
AC	0.412	0.387	0.575	0.524	0.907			
US	0.397	0.399	0.545	0.529	0.689	0.909		
NV	0.355	0.353	0.515	0.490	0.692	0.736	0.927	
UI	0.376	0.335	0.353	0.345	0.193	0.235	0.180	0.918

Correlation of Latent Variables- 2nd order

	UI	IQ	SQ					
UI	0.918							
IQ	0.418	0.853						
SQ	0.230	0.597	0.896					

RL: relevance; RI: reliability; TL: timeliness; SP: scope; AC: access; US: usability; NV: navigation; UI: usage increase; IQ: information quality; SQ: system quality

Discriminant validity(Decrease group: N=168)

Correlation of Latent Variables- 1st order

	RL	TL	RI	SP	AC	US	NV	UD
RL	0.880							
TL	0.421	0.649						
RI	0.405	0.531	0.885					
SP	0.344	0.492	0.431	0.858				
AC	0.168	0.296	0.312	0.164	0.879			
US	0.209	0.341	0.335	0.369	0.551	0.865		
NV	0.185	0.361	0.453	0.389	0.591	0.707	0.893	
UD	0.101	-0.034	-0.05	0.057	-0.194	-0.047	-0.137	0.942

Correlation of Latent Variables- 2nd order

	UD	IQ	SQ					
UD	0.942							
IQ	0.266	0.693						
SQ	0.132	-0.141	0.799					

RL: relevance; RI: reliability; TL: timeliness; SP: scope; AC: access; US: usability; NV: navigation; UD; usage decrease; IQ: information quality; SQ: system quality

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