MOBILE WORK SUPPORT

THE NATURE OF MOBILE WORK AND THE NEEDS FOR MOBILE WORK TECHNOLOGY SUPPORT – A TASK-TECHNOLOGY FIT PERSPECTIVE

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ABSTRACT

The rapid growth in the use of wireless communication and portable devices in recent years has created a great potential for a variety of mobile work technology support. However, we still lack the theories to explore the nature of mobile work, examine the needs for mobile work support, and identify the appropriate mobile technologies for various kinds of mobile work. This study is an attempt to meet the challenge.

A mobile task model is proposed in this study which includes four dimensions: task complexity, task interdependence, time criticality, and location sensitivity. New instruments are developed to measure the constructs of time criticality and location sensitivity. Six typical mobile work support functions are examined: mobile communication, mobile information searching, mobile transaction processing, location related service, mobile job dispatching and mobile office. In light of contingency theory and attitude/behavioral theory, a research model is proposed to identify the ideal fit between task characteristics and typical mobile work support functions.

Based on empirical data from real mobile workers, the nature of mobile work and the differences in mobile work between mobile knowledge workers and field workers are analyzed. New instruments for the time and location related constructs are validated through the empirical data. The differences in perceived usefulness of the typical mobile work support functions between mobile knowledge workers and field workers are presented, as well as those of the current usage and intention to use. Finally, the ideal fit is identified on the basis of the empirical data.

This study contributes both to theory and practice. The establishment of a mobile task model, including the development of new instruments for time and location constructs, provides a foundation for future mobile business research. The identification of the ideal fit between task characteristics and mobile technology functions, based on contingency theory and attitude/behavioral theory, extends and enriches mobile business research. The results of the study can provide guidance and recommendations on how to strategically plan and implement suitable mobile applications, and to identify opportunities for the development of appropriate technological solutions for mobile work support.

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Chapter 1: Introduction

1.1 Research Background

The rapid growth in the use of wireless communication and portable devices in recent years has created a great potential for a variety of mobile work technology support. The implementation of mobile work support brings a competitive edge as well as improves work productivity for business (Barnes 2003; Chen and Nath 2004). However, mobile work support applications do not necessarily with any certainty bring value to mobile work. Not all mobile tasks require or can benefit from the use of mobile work support, nor do all types of mobile work support guarantee that they will be of value. As shown in a case by Luff and Heath (1998), the utilization of mobile technologies may be problematic, and mobile technologies may be used in unexpected ways. For example, mobile devices were introduced to provide communication and collaboration support between foremen and field workers at a construction site. However, the usage of mobile devices actually did not facilitate work collaboration. Instead of being used as a collaboration tool, mobile devices were primarily used by workers as a data collection device. This does not mean that mobile devices are not useful tools, but merely demonstrates that they are not useful in some specific situations (Luff and Heath 1998). Therefore, identifying the appropriate mobile technologies for various kinds of mobile work is critical to achieving value from mobile work support applications.

Despite the great potential of mobile technologies, we still lack theories to fully understand the nature of mobile work. Without this understanding, it will be difficult to identify the needs for mobile work support applications developed for mobile workers. The pivotal focus of existing information systems research has been mainly focused on stationary office environments. It is time for IS (Information Systems) research to "move on or move over", i.e., to identify what theories are still valid and what theories are no longer adequate and need to be extended. The demands of mobile work support require us to rethink many fundamental assumptions underlying IS research (Lyytinen and Yoo 2002). The research in this thesis is an attempt to contribute to the extending the fundamentals of IS theory in the new mobile environment.

1.2 Research Objectives and Research Questions

The objective of this study is to explore the nature of mobile work, to examine the needs for mobile work technology support, and to identify the ideal fit between the characteristics of mobile tasks and mobile functionalities.

The research questions of this study are presented as follows. The first research question is: What is the nature of mobile work? To answer this question, we need to address the following four sub-questions: 1) How should mobile tasks be modeled? 2) What are the characteristics of mobile tasks? 3) How can mobile tasks be evaluated? and 4) What are the key differences in mobile work between different types of mobile workers?

The second research question is: What are the typical functions that are used to support mobile work? To answer this question, we need to address the following sub-questions: 1) What are the typical mobile technology functions needed to support mobile work? 2) How are these functions related or clustered? 3) What are the differences between different types of mobile workers in terms of their current usage of, perceived usefulness of, and intention to use mobile technology functions? and 4) What is the gap between the current usage of these functions and worker intentions to use them?

The third research question is: What is the ideal fit between the characteristics of mobile tasks and mobile technology support functions? Before answering this question, we need to: 1) address how to define and measure this fit and 2) find the ideal fit, based on empirical data analysis.

To respond to these questions, this study will propose a model to describe mobile tasks in four dimensions: 1) task complexity, 2) task interdependence, 3) time criticality, and 4) location sensitivity. While using existing instruments to measure task complexity and task interdependence, new instruments for time criticality and location sensitivity must be developed and validated through the analysis of empirical data. The nature of mobile work is to be explored, based on empirical data. Based on an investigation of currently existing mobile technology functions, six typical mobile technology functionalities are identified: 1) mobile communication, 2) mobile information searching, 3) mobile transaction processing, 4) mobile job dispatching, 5) location related service, and 6) the mobile office. The current usage of, perceived usefulness of, and intention to use these mobile technology functions are examined through empirical data. After a thorough and comprehensive literature review, especially of contingency theory and its applications in information systems research, this study defines this fit as the congruence between task characteristics and the functionality of the technology that improves work performance. It then uses perceived usefulness to measure the fit. Finally, the ideal fit between the characteristics of mobile tasks and mobile functionalities is explored through the analysis of empirical quantitative data.

This study aims to contribute to both theory and practice. With respect to theory, the primary objectives are: to explore the nature of mobile work based on a theoretical task model, to examine the usefulness of mobile work technology support functions, and to identify the ideal fit between task characteristics and mobile technology functions. Regarding practice, the purpose of the study is: to provide guidance and recommendations on how to strategically plan and implement suitable mobile applications, and to help identify opportunities for the development of appropriate technological solutions to support mobile workers.

1.3 Organization of the Thesis

The thesis consists of seven chapters. Chapter 1 (this chapter) introduces the research background and the motivation for the study, presents research objectives and research questions, and highlights the expected contributions to both theory and practice.

Chapter 2 offers a comprehensive review of related work on mobile work technology support, including the definition of mobile workers, the nature of mobile work, the support technologies for mobile work, and the utilization of mobile technology for mobile work.

Chapter 3 presents a thorough review of the theoretical background for this study. Contingency theory and attitude/behavior models are discussed. The applications of contingency theory in information systems research, the concept of fit and how to measure the fit are addressed in detail.

Chapter 4 proposes a research model. The task model is then presented. Four dimensions of the task model are discussed in detail. Mobile technology and the six typical mobile work support technology functions are discussed. The chapter concludes with the development of the research hypotheses.

Chapter 5 discusses the methodology utilized in this study. Measurements of constructs and instrument validation methods are introduced, along with sampling and data collection methods. Finally, data analysis methods are presented.

Chapter 6 offers data analysis and results. First, the data collection procedure and the profiles of survey respondents are introduced. Second, instrument validation is discussed. Third, the nature of mobile work is analyzed. Fourth, the usage of mobile technology supported is discussed. Fifth, hypotheses testing is conducted through multiple regression and a structural equation model.

Chapter 7 offers conclusions from the study. First, the research questions posed in the introduction are answered. Second, research contributions from the study are presented, followed by a discussion of the limitations of the study, and suggested avenues for future research.

Chapter 2: Related Studies of Mobile Work Technology Support

The objectives of the review of related studies are: (1) To review the status of relevant mobile work support studies; (2) To discuss flaws and weaknesses of existing studies; (3) To organize existing literature as the basis for this study.

The work reviewed in this chapter is summarized in Table 1. In this chapter, definitions of mobile workers are reviewed, followed by a review of studies on the nature of mobile work. Next, studies of characteristics of mobile technology and categorization of mobile applications are discussed. Then studies are introduced about why and how mobile applications are used by mobile workers, and finally, comments arising from the chapter are presented.

2.1 Definition of Mobile Work

In this section, we will review the studies that answer the following questions: Who are mobile workers? What is the categorization of mobile workers?

First, we need to clarify the concept of mobility. There are many different views of this concept. Mobility has been viewed as the physical mobility of persons, either by walking or by some means of transportation; it has also been viewed as information mobility by means of broadcasting media such as television or the Internet, or the mobility of objects (Urry 2000). There are also concepts of social mobility and economic mobility (Smith and Katz 1993; Urry 2000). In our research, we define mobility as the physical movements of people

Table 1: Framework of Literature Review

Review subject	Review objectives	Review results
Definition of mobile workers	What is the concept of mobility?	Mobility refers to people's physical movements (Urry 2000)
	Who are mobile workers?	Mobile workers are workers who are away from their office desks for more than 20 percent of the work time (Gartner 2002).
	What is the categorization of mobile workers?	In terms of job category, there are two types of mobile workers: mobile knowledge workers and field workers (Yuan and Zheng 2006). In terms of degree of mobility, there are five types of mobile workers: On-site movers; Yo-yos; Pendulums; Nomads; Carriers (Lilischkis 2003).
Nature of mobile work	What are the characteristics of mobile work compared to stationary work?	Uncertainty, lack of awareness and connection, dynamic time structure were mentioned in the literature. Characteristics of mobile work were summarized and compared with stationary work by Yuan and Zheng(2005); Zheng and Yuan(2006).
	Are there studies that try to establish a theoretical model to describe mobile work?	A conceptual model for describing mobile work was proposed by Yuan and Zheng(2005); Zheng and Yuan(2006). Not tested by empirical study.
Support technology for mobile work	What are the characteristics of mobile technology?	Portability, Ubiquity, Uniqueness, and Context Awareness (Watson et al. 2002)
	What are the typical functionalities of mobile applications? How to categorize them?	No widely accepted categorization of mobile technology support functions.

Table 1: Framework of Literature Review (Cont.)

Review subject	Review objectives	Review results
Utilization of mobile technology in mobile work	What factors determine/affect the adoption of mobile applications by mobile workers?	Attitude/behavior theory is used, mostly for mobile consumer service adoption
	In which situation can mobile technology support improve the performance of mobile work?	- Identify fit profile between location dependence/time dependence and ubiquity/uniqueness (Junglas and Watson 2003). - Mobile procurement system for urgency and structured process situations (Gebauer and Shaw 2004)

from one place to another and/or temporary stays in places other than their own fixed offices. The mobile workforce is defined as workers who are usually away from their office desks for more than 20 percent of the work time, or who do not have office desks (Gartner 2002).

Mobile workers can be classified by industry. The typical mobile workforce includes managers, sales force, transportation workers (such as truck drivers, taxi drivers), field service workers, emergency workers, healthcare professionals, etc. (Gartner 2002). We can generally categorize these mobile workers into two types: one is mobile knowledge workers (MKW), mainly including managers, salesperson, and mobile professionals. The other is mobile field workers (MFW), mainly including transportation/delivery workers, field service workers, and emergency workers (Yuan and Zheng 2006).

Mobile workers can also be classified by patterns of mobility. In one of the earlier studies of mobile work, Whittaker et al. (1994) distinguished two types of mobile professionals. One was primarily mobile in the local office environment, the other was mobile in both the local office and also remotely (within the local metropolitan area) (Whittaker et al., 1994). Local mobility (defined as within easy walking distance of the office, such as walking between rooms or buildings at a local site) was further examined in an ethnographic field study of a distributed design team by Bellotti and Bly (1996).

Kristoffersen and Ljungberg (2000) further distinguished two kinds of remote mobility: traveling and visiting. Thus they contended that there are three types of mobility, which they called wandering, traveling and visiting. Wandering is an activity characterized by extensive local mobility. Traveling is an activity that takes place while traveling in a vehicle or walking. Visiting is an activity that happens in one place for a coherent but temporal period of time (Kristoffersen and Ljungberg 2000).

Lilischkis (2003) distinguished five types of mobile work in terms of an increasing level of detachedness of the workplace (Lilischkis 2003). Every mobile worker performs one or another kind of mobile work sometime, and some mobile workers may perform many types of mobile work in a certain period of time. These five types of mobility are discussed below:

(1) "On-site movers": work requiring movement around a certain site. "On-site movers" are working on a certain site but have to move around or back and forth

for certain purposes. Examples are security agents walking around and watching sites, and hospital doctors visiting patients.

(2) "Yo-yos": occasionally working away from a fixed location. The definition of the yo-yo type of mobile work refers to a fixed location as a reference point that is left for a certain time to work elsewhere. People may leave the workplace for meetings, customer visits, and the like, from time to time.

(3) "Pendulums": alternate working at two different fixed locations. The pendulum type of mobile work includes work with two fixed work locations such as the employer's premises, a home office, or a client's premises, between which the workers alternate. The pendulum type includes the classical telework: work being carried out at a distance, implying computer use, and the use of telecommunication for electronically exchanging work results and messages with colleagues, superiors, or external agents such as clients.

(4) "Nomads": working at changing fixed locations. The nomad type of mobile work refers to people who constantly move from one work location to another. The number of work locations is more than two, otherwise they would be classified as pendulums. Field sales forces as in the insurance business may visit many customers a day and could be considered to be "nomads" in a wider sense.

(5) "Carriers": working on the move transporting goods or people. The definition of the carrier type of mobile work refers to personal or commodity transportation involving continuous moving from one place to another. Examples are jobs such as truck drivers and taxi drivers.

In this study, mobile workers classed as pendulums, such as tele-workers, are not included since they differ in special ways from other mobile workers. Dix and Beale (1996) make the distinction by claiming that telework is dependent upon spatial location, i.e., the home, a hotel room etc. Telework, broadly defined, means "working at a distance". The most popular example is the person who works at home instead of commuting to a distant office. A mobile worker is one whose "place of work" isn't fixed at all, and who needs to be effective in a range of different work settings (Dix and Beale 1996).

2.2 Nature of Mobile Work

In this section, we review studies that answer the following questions: What are the characteristics of mobile work as compared with stationary work? Is there a theoretical framework to describe mobile tasks?

2.2.1 Characteristics of Mobile Work

In the literature, the following three characteristics of mobile work are discussed: uncertainty, lack of connection, and temporal mobility.

Many studies have found that uncertainty is the main characteristic of mobile work. Perry et al.'s study of mobile workers traveling on business discovered that mobile work is unpredictable (Perry et al., 2001), and that this is one of the major difficulties in mobile work. Hence, one of the important features for mobile workers is how to deal with uncertainty. Tamminen et al. described situational (unplanned) actions within planned ones (Tamminen and Oulasvirta 2004). For mobile workers, there are inherent uncertainties associated with place that impact on their work choices and the kinds of activities they pursue, and managing the uncertainty of place is of particular concern to mobile workers (Brown and O'Hara 2003). Tamminen and Oulasvirta found that location-related problems are usually solved through interaction with other people. When people on the move come up against obstacles, or are simply feeling unable to navigate their routes correctly, they often seek help via interaction with others (Tamminen and Oulasvirta 2004). In this study, this kind of problem was solved with the help of a mobile phone.

Maintaining informal awareness of what is going on in the office, and building a sense of community, are important for mobile workers. Evidence for this is seen in the workplace design literature (Tanis and Duffy 1999) and in studies of informal communication (Whittaker et al., 1994; Luff and Heath 1998). Awareness and communication problems were also discussed in Luff and Heath (1998)'s mobility studies. One example comes from their observations of staff and management at the London Underground. In this case, many of the information and communication resources required for the staff to perform their work were located in the operations room. When members of staff were mobile and away from this room, they were unable to access the ongoing changes taking place in it: the staff member no longer had continuous visual and auditory access to colleagues and information gained by inadvertently overhearing conversations and phone calls (Luff and Heath 1998). Perry et al.'s study also showed that one of the problems faced by mobile workers away from the office is how to maintain an informal awareness of what is going on back at the office and also how to maintain a sense of community at work (Perry et al., 2001). Mobile technologies can potentially help support these aspects of work, and these researchers saw some evidence of this.

The temporal structure of mobile work is highly varied and fluctuating (Tamminen and Oulasvirta 2004). Tamminen et al. (2003) called this temporal tension. Temporal tension could be classified into four stages: acceleration, normal (anticipated) proceeding, slowing down, and stopping. Some situations get accelerated. Sometimes, they get "slower", or even "stop". The two important tensions emerging from the study of Tammine et al. (2003) are hurrying and waiting. When hurrying, people are actively orienting to the temporal aspects of their actions. They are managing their current activities to fit in a time frame - the planned action is not unfolding as anticipated, and more "doings" must be squeezed into the same amount of time than in a normal situation, to keep up with the original plan. When waiting, the relationship between time and action is stretched. The waiting time can then be used in various time-killing activities (e.g., by reading, playing games, or calling somebody). This waiting time is called "dead time" (Perry et al., 2001). During travelling, there are often large amounts of time when mobile workers have nothing to do or cannot do something. This time occurs between tasks and between meetings, in which the mobile workers usually have little control over the resources available to them (Perry et al., 2001).

2.2.2 Framework to Describe Mobile Work

Some studies have tried to establish a framework that can be used to characterize mobile work, with most of them trying to use time and location as the main dimensions of the framework. For example, Wiberg and Ljungberg proposed a conceptual framework that analyzes mobile tasks along the two dimensions of time and space. Combinations of the two dimensions produce four scenarios of mobile work. The four scenarios of the model are (Wiberg and Ljungberg 1999):

(1) "Anytime, anywhere": Tasks that can be done independent of time and place. They can be done anytime, anywhere.

(2) "Anytime, particular place": Tasks that need to be done at a particular place but can be done whenever.

(3) "Particular time, any place": Tasks that can be done independent of place but at a certain time or in a certain order.

(4) "Particular time, particular place": Tasks that must be done at a particular place and on a particular time.

Saugstrup and Henten (2003) proposed a preliminary framework of mobile work, in which location (that is the geographical parameters in their model) and time are the main dimensions (Saugstrup and Henten 2003):

(1) Geographical parameters. Starting with Kristoffersen and Ljungberg's (2000) definitions of mobile modalities, wandering, visiting, they further

categorized visiting modality into three sub-modalities/levels: world traveler, regional traveler, and local traveler.

(2) Time parameters. The time parameters consist of two aspects: being dependent or independent of time regarding communication and interaction, and being synchronous or asynchronous regarding communication patterns.

Junglas and Watson (2003) proposed three dimensions to describe mobile tasks: time-dependent, location-dependent, and identity-dependent tasks.

(1) Time-dependent tasks are those that have to be fulfilled as soon as possible. Depending on whether the task is initiated by the task doer or triggered by someone external, the taxonomy distinguishes between intrinsic and extrinsic time-dependent tasks.

(2) Location-dependent tasks are those that require location information either about the person (intrinsic), or about somebody else (extrinsic).

(3) Finally, identity-dependent tasks are those that require a unique identification of a person, including his/her preferences. Identity information can either be provided about the person (intrinsic, e.g., billing information), or about others (extrinsic, e.g., personal preferences for one-to-one marketing).

Gebauer et al. (2005) extended the traditional task model with two traditional task dimensions (task difficulty and task interdependence) into the mobile context by adding the third dimension of time criticality. Time criticality is defined as the importance with which a task needs to be performed promptly (urgency) (Gebauer et al., 2005).

Yuan and Zheng (2005) and Zheng and Yuan (2006) proposed a conceptual framework and used this framework to analyze four fundamental aspects of mobile work: mobile workers, mobile tasks, mobile context, and mobile technology. Besides the traditional task dimensions of task complexity and task interdependence, time and location dimensions were emphasized in their model.

Most of the foregoing studies do not provide empirical evidence to verify their models.

2.3 Supporting technology for mobile work

In this section, we will review the studies that answer the following questions: What are the characteristics of mobile technology? How should mobile applications be categorized?

2.3.1 Characteristics of mobile technology

It is generally accepted that portability, ubiquity, uniqueness and context awareness are the main characteristics of mobile technologies.

Clarke contended that the unique characteristics of mobile applications are found in the specific dimensions of ubiquity, convenience, localization, and personalization (Clarke 2001). Mobile devices offer users the ability to receive, send, and process information from virtually any location on a real-time basis. The agility and accessibility provided by wireless devices enable people to access mobile services without constraints of time and place. Location-specific information leverages the key proposition of mobile commerce over traditional e-commerce by supplying information relevant to the current geographic position of the user. Mobile devices are typically used by a single individual, making them ideal for target marketing of individuals.

Watson et al. proposed that mobile technology is characterized by four Us: ubiquity, universality, uniqueness and unity (Watson et al., 2002). Ubiquity relates to the "anytime-anywhere" access focus, which the mobile phone with associated networks is fast bringing to reality. The convergence of network access is enabling universality. The ability to individualize information and provide pull information based upon location, time, role, or some combinations brings the promise of uniqueness. This is also called context awareness. Synchronization of access devices, information provision, and software drivers are essential pre-requisites for the success of the four Us.

2.3.2 Categorization of Mobile Application Functions

Functions of mobile applications have often been described by mobile product and service providers. In the academic world, there are no widely accepted categorizations of mobile applications. However, some progress is indicated from the following two studies.

Liang and Wei classified mobile applications into six categories (Liang and Wei 2004):

- **Time-Critical Services.** This category of application provides emergency and time-critical services, such as mobile notification, and event-trigger messaging.
- **Location-Aware and Location-Sensitive Services.** A location-aware service is one for which the location information of moving targets is important to the delivery of the service. Location-sensitive services rely on location information about moving targets for delivering "relevant" and "appropriate" services.
- **Identity-Enacted Services.** Mobile devices can be used to identify users. Examples of identity-enacted services include mobile financial applications (e g., mobile banking and brokerage services, mobile money transfer, and mobile micro-payments) that allow customers to conduct financial transactions. User-sensitive mobile advertising is another identity-enacted service.
- **Ubiquitous Communications and Content Delivery Services.** Mobile communications facilitate personal contact anytime, anywhere. While voice and short message service (SMS) are currently the primary form of mobile communication, future mobile devices such as 3G phones are capable of handling much more information and providing broader bandwidth.
- **Business Process Streamlining.** Mobile services can be used to enhance the efficiency of business processes that include location-sensitive or time-

critical activities to reduce transaction costs or improve service quality. On-the-spot claim payment processing is one example.

- **Mobile Offices.** Mobile devices may be used within or external to offices. Mobile workers (i.e., workers equipped with mobile applications) are able to retrieve critical information from central office systems, perform job assignments, scheduling, and dispatch, and collaborate with others (mobile or not) in a wireless environment.

Balasubramanian et al. proposed that mobile applications be categorized along three dimensions (Balasubramanian et al., 2002): (1) the extent to which the application is location sensitive, (2) the extent to which the application is time critical, and (3) the extent to which the application is controlled by the information receiver or by the provider.

Applications vary along the first dimension (location) in terms of how "tied in" they are to the physical location of the information recipient. In some cases, applications may closely relate to the surrounding physical environment (e.g., mapping one's location using a satellite-based GPS (Global Positioning System)). In other cases, applications may be entirely independent of physical location (e.g., obtaining a stock quote over a cellular phone). Generally, when an application is related to the surrounding physical environment, it will involve interactions with a fixed physical asset in that environment (e.g., repairing on the spot), a repositioning of the receiver unit within that environment (e.g., truck rerouting), or information generated about the environment itself (e.g., GPS-based mapping).

Applications vary along the second dimension (time) in terms of the degree to which they are time critical. At one extreme, applications may be highly time critical (e.g., emergency handling); at the other extreme, applications may not be time critical at all (e.g., meter reading). In general, when an application is time critical, it will involve the exchange of information related to a scheduled event (e.g., an appointment with a customer), information that quickly depreciates in value (e.g., a stock price), or information that is required to address some emergency (e.g., a roadside assistance request).

Finally, applications vary along the third dimension (control) in terms of whether they are controlled by an information receiver (e.g., a taxi driver) or a provider (e.g., a dispatcher). Applications controlled by a receiver of information would tend to relate to more random, unforeseen needs (e.g., a call for service after an automobile breakdown). In contrast, applications controlled by a provider would tend to be marketing "broadcast" activities (e.g., announcement broadcasts according to geographical proximity) and applications that are maintained on an ongoing basis by service providers or coordinators (e.g., monitoring of truck fleets using onboard sensors in conjunction with satellite-based sensing and communication systems).

2.4 Utilization Studies of Mobile Applications

In this section, we will review the studies that answer the following questions: What factors affect and lead to the adoption of mobile applications by mobile workers? In which situation might or might not a specific mobile application improve the performance of mobile work?

In recent times, many studies have been conducted to analyze the factors that affect and lead to the adoption of mobile services (e.g., Lee 2002; Pedersen 2002; Bruner II 2003; Fang 2003; Hung 2003; Wu and Wang 2005; Wakefield and Whitten 2006). Most of these studies have applied existing adoption models of information systems or their extensions. The constructs that are typically used in these studies include: Perceived usefulness, Perceived ease of use, Subjective norm (Peer influence, External influence), Image, Connection speed, Service costs, User satisfaction, Personal innovativeness, Perceived playfulness/Fun, Perceived security, Consumer visual orientation, Internet device, Self-efficacy, Facilitating condition, and Service Quality. Most of these studies have been in the consumer field, with very few in the business field.

Many scholars have argued that for an information system to have a positive impact on performance the technology must be a good fit with the task it supports (Goodhue and Thompson, 1995, Zigurs and Buckland, 1998). TTF (Task-technology Fit) provides a conceptual basis for explaining in which way the nature of the task impacts individual and organizational performance (Goodhue and Thompson, 1995). There are two studies (Junglas and Watson (2003) and Gebauer and Shaw (2004)) that used the TTF model or a combination of the TTF model and TAM (Technology Acceptance Model) to explore the ideal fit between mobile tasks and the functions of mobile applications. These studies focused on determining where mobile applications could improve the performance of mobile work.

Junglas and Watson (2003) distinguished between three different levels of fit: ideal fit, over-fit, and under-fit. Whereas ideal fit reflects the ideal mapping of ubiquity and uniqueness task characteristics and technological functionality, over- and under-fit, respectively, describe a digression from the ideal mapping. In the case of over-fitting, technology provides more functionality than required for the task. In the case of under-fitting, a technology does not provide sufficient functionality to perform that task efficiently. These authors propose that ideal fit will lead to the highest level of individual performance, usefulness, and ease of use, whereas over-fit is expected to lead to a high level of performance, usefulness, and ease of use, but not to the same extent as ideal fit. Under-fit, in contrast, is expected to lead to the lowest levels of all three. The fit profile identified is shown in Table 2.

Table 2: Fit Profile in Janglas and Watson's (2003) Study

	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L
Ti-H/Lo-H	Ideal fit	Under-fit	Under-fit	Under-fit
Ti-H/Lo-L	Over-fit	Ideal fit	Under-fit	Under-fit
Ti-L/Lo-H	Over-fit	Under-fit	Ideal fit	Under-fit
Ti-L/Lo-L	Over-fit	Over-fit	Over-fit	Ideal fit

Ub – Ubiquity; Un – Uniqueness
Ti – Time dependence; Lo – Location dependence
L – Low; H – High

Gebauer and Shaw (2004) conducted a case study of a Fortune 100 company that was developing and introducing a WAP-enabled mobile application to enhance its procurement system. Their study found that users value two things most: notification and support for simple activities, as opposed to handling more complex processes completely on-line. Their study also indicated that it is critical to develop simple yet functional solutions.

Gebauer and Shaw's study verified that it is often easier to support or automate structured and semi-structured tasks with mobile transaction processing, while unstructured tasks often rely more on the use of mobile information access and mobile communication (Gebauer and Shaw 2004). They proposed that: (1) Workers performing highly structured tasks tend to use mobile business applications for data processing, and (2) Workers performing unstructured tasks tend to use mobile business applications for accessing information and for communication purposes. In their study, the tasks of finance and accounting approvers were much more structured than the tasks of their approving managers. Consequently, the approving managers reported longer time spent because of missing information and actually making approval decisions. For the finance approvers, decisions were more straightforward, providing evidence for the fact that their decisions depended largely on compliance with procedural requirements and not so much on managerial decision-making. As soon as all the necessary information was provided, decisions could typically be made instantly. Compared to approving managers, finance and accounting approvers indicated a higher percentage of approvals that could be submitted via the mobile system. Approving managers, however, indicated a higher percentage of approvals where the mobile application could support communication and access to information.

Gebauer and Shaw (2004) also examined the proposition that the use of mobile business applications is positively related to the perceived need to handle emergency situations. In their study, several participants acknowledged the fact that the mobile application could help address emergency situations. For example, one finance approver acknowledged a need for continuous system access for people who traveled frequently and who were the final decision makers on high value ad hoc and unplanned purchases that were urgent and required immediate approval. Another finance approver indicated that she tried to respond to requests as quickly as possible given that she did not know the urgency of individual requests. She had experienced situations where requestors had waited for her to get back from lunch to get her final sign-off, before the purchase order could be sent off to the supplier. This finance approver also described an incident where her swift reaction to an urgent approval request helped secure a major deal for the customer. Another finance approver indicated that requests he processed were not urgent and could thus be handled by the administrative assistant in his absence. The finance approver cited this arrangement as the reason why he did not want to use the mobile application (Gebauer and Shaw 2004).

2.5 Comments and Discussion on Literature Review

Firstly, there have been a number of studies on the definition of mobility, mobile work, and different types of mobile workers. We can therefore adopt these definitions from the existing literature. That is, mobility is defined as physical movement of people from one place to another and/or temporary stays at places other than their own fixed office (Urry 2000). The mobile workforce consists of workers who are usually away from their offices for more than 20 percent of work time, or who may even not have office desks (Gartner 2002). Mobile workers can be categorized into mobile knowledge workers and field workers (Yuan and Zheng 2006). And mobile work can be classified into the following five types: On-site movers, Yo-yos, Pendulums, Nomads, and Carriers (Lilischkis 2003).

Secondly, some studies have found that mobile work has the characteristics of uncertainty (Perry et al., 2001; Tamminen and Oulasvirta 2004), lack of awareness and connection (Luff and Heath 1998; Perry et al., 2001), and highly varied temporal structure (Perry et al., 2001; Tamminen and Oulasvirta 2004). While some literature has proposed frameworks that try to characterize mobile work (Wiberg and Ljungberg 1999; Junglas and Watson 2003; Saugstrup and Henten 2003; Gebauer et al., 2005), there is as yet no theoretical and systematic framework for the nature of mobile work. Time and location (or place) were emphasized by Wiberg and Ljungberg (1999), Junglas and Watson (2003), and Saustrup and Henten (2003), but they ignored the traditional task dimensions: task complexity and task interdependence. Gebauer et al.'s (2005) task framework includes the two traditional task dimensions plus time criticality. It is therefore a good framework for describing mobile tasks, but their task framework doesn't include a location-related dimension. Yuan and Zheng's (2005) and Zheng and Yuan's (2006) conceptual model for describing mobile work includes the traditional task dimensions (task complexity and task interdependence) and the time and location dimensions. None of the existing literature includes the operationalization of time and location constructs.

Thirdly, as to the characteristics of mobile work technology support, it is widely accepted that portability, ubiquitous connection, location awareness, and identity are the main characteristics of mobile technology (Watson et al., 2002; Clarke 2001). However, on the functionality level, there is no accepted classification of mobile application functionalities. Liang and Wei's (2004) and Balasubramanian et al.'s (2002) studies are good attempts to classify mobile application functionalities, but they do not fully meet the five criteria for evaluating classification schema that were proposed by Hunt (1983), i.e., whether the schema: (1) adequately specifies the objects to be classified, (2) adequately defines the characteristics to be used as a basis for classification, (3) defines categories which are mutually exclusive, (4) is collectively exhaustive, and (5) is useful..

Fourthly, as to the utilization study of mobile applications, most existing literature focuses on mobile commerce, i.e., in consumer fields. Most of these studies used an attitude/behavior model (such as TAM) as their theoretical background (e.g., Lee 2002; Pedersen 2002; Bruner II 2003; Fang 2003; Hung 2003; Wu and Wang 2005; Wakefield and Whitten 2006), some of them used the Task-Technology Fit model (Gebauer and Shaw 2004; Lee et al., 2004) or a combination of TAM and TTF model (Junglas and Watson 2003). While TAM is powerful and has been verified by many studies, one major drawback it has is that the nature of the task is not included (Junglas 2003). As to the utilization of mobile technology in mobile work, there is only one relevant study, i.e., Gebauer and Shaw's (2004) case study. They conducted a case study on a procurement system based on the TTF model. Their study is of great value to mobile business studies. However, they only investigated one application, and there is no theoretical and systematic task model in their study.

Chapter 3: Theoretical Background

Information systems research has long recognized the importance of understanding how and why people use information systems (Junglas 2003). During the past decade, two significant theories have emerged which provide a strong theoretical base for studies of information system utilization behavior: attitude/behavior theory and contingency theory. This study will be based on these two streams of theory. There have been two general applications of contingency theory in information systems research: the Information Processing Model in which uncertainty is the key concept, and the Task-Technology Fit (TTF) Model. In the TTF model, there are three kinds of concept of fit: fit as congruence, fit as interaction, and fit as absolute fit. For fit as congruence, there are two conceptualizations of fit: subjective and objective. For subjective conceptualization of fit, there are also two methods to measure the fit: predicted outcomes and facets of fit. In this study, we will use the predicted outcomes to measure fit. Specifically, we will use perceived usefulness to measure fit. We will explain the theoretical background following the framework shown in Figure 1.

3.1 Attitude/behavior Theory

According to attitude/behavior models, characteristics of information technology lead to user attitudes about the system. These attitudes, along with social norms and other situational factors, lead to utilization. This stream of

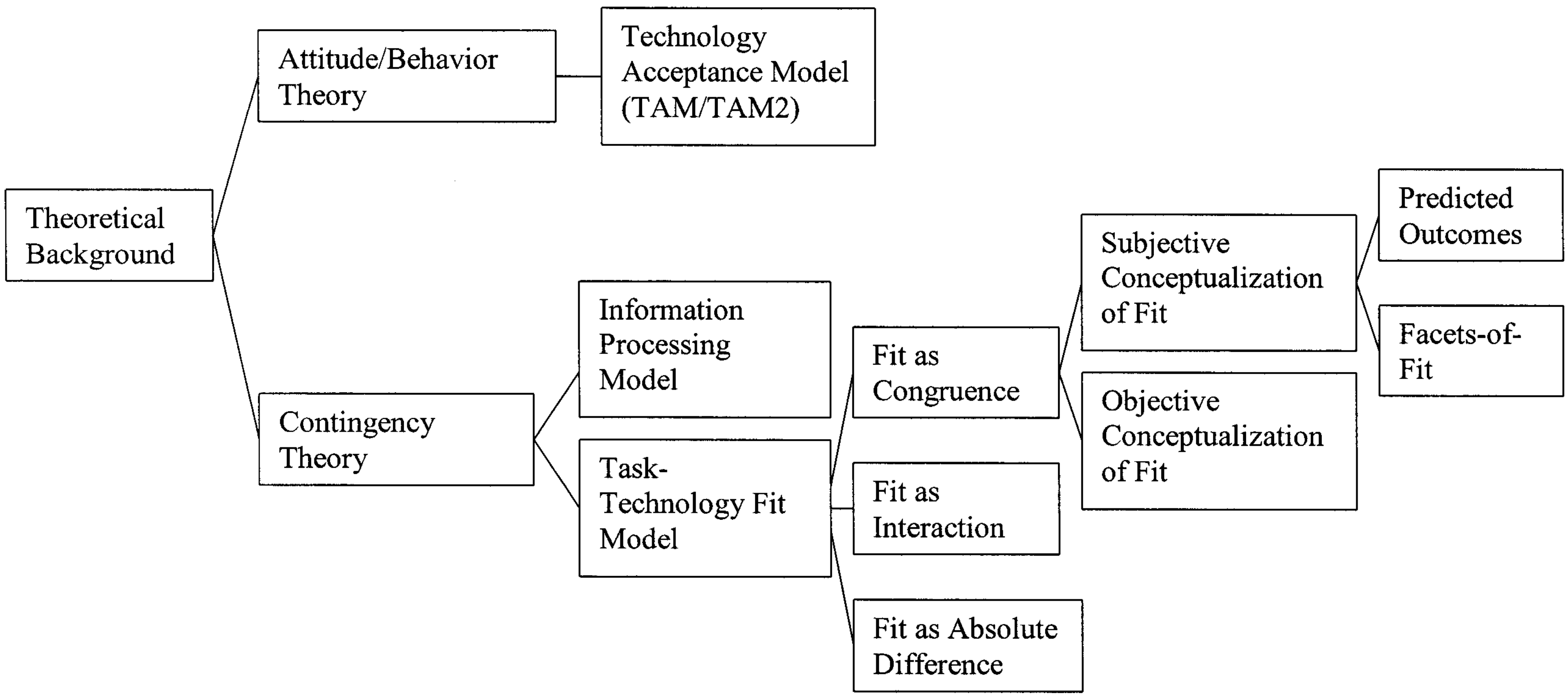

Figure 1: Theoretical Background

research focuses on individual acceptance of technology by using intention and/or usage as a dependent variable (e.g., Davis 1989; Compeau and Higgins 1995). The role of intention as a predictor of behavior (e.g., usage) is critical in attitude/behavior models. Drawn from social psychology, Theory of Reasoned Action (TRA) is one of the most fundamental and influential theories of human behavior. In this model, the core construct is attitude toward behavior (an individual's positive or negative feelings (evaluative affect) about performing the target behavior) and subjective norm (the person's perception that most people who are important to him/her think he/she should or should not perform the behavior in question) (Fishbein and Ajzen 1975). Unlike TRA, the final conceptualization of the Technology Acceptance Model (TAM) excludes the attitude construct in order to better explain intention parsimoniously (as shown in Figure 2). This model contends that perceived usefulness (the degree to which a person believes that using a particular system would enhance his or her job performance) and perceived ease of use (the degree to which a person believes that using a particular system would be free of effort) will lead to intention to use (Davis 1989). TAM2 extends TAM by including subjective norm as an additional predictor of intention in the case of mandatory settings (Venkatesh and Davis 2000). Theory of Planned Behavior (TPB) extends TRA by adding the construct of perceived behavioral control (the perceived ease or difficulty of performing the behavior). In the context of IS research, these are perceptions of internal and external constraints on behavior (Ajzen 1991; Taylor and Todd 1995). After examining the previous adoption models, Venkatesh et al. (2003) proposed a Unified Theory of Acceptance and Use of Technology (UTAUT). They argue that four constructs will play a significant role as direct determinants of user acceptance and usage behavior (Venkatesh, Morris et al. 2003): performance expectancy (the degree to which an individual believes that using the system will help him or her to attain gains in job performance), effort expectancy (the degree of ease associated with the use of the system), social influence (the degree to which an individual perceives that important others believe he or she should use the new system), and facilitating conditions (the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system).

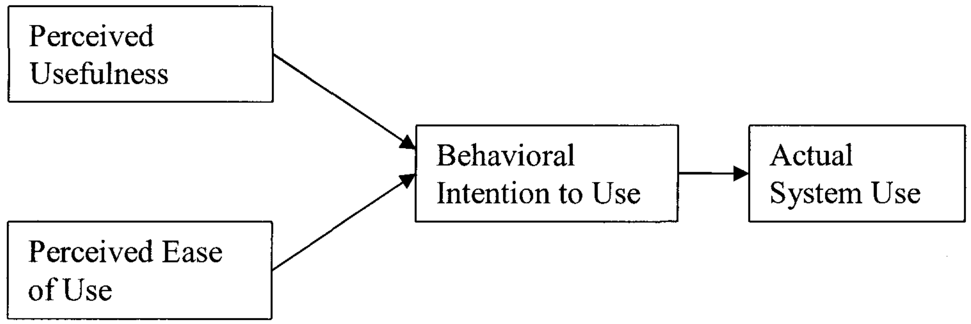

Figure 2: Technology Acceptance Model (Davis 1989; Ajzen 1991)

3.2 Contingency Theory

The other theory that is used in IS utilization studies is contingency theory. At the most abstract level, contingency theory contends that the effect of one variable, X, on another, Y, depends upon some third variable, W. Thus the effect of X on Y when W is low differs from the effect of X on Y when W is high. For example, it might be that when W is low, X has a positive effect on Y, whereas when W is high, X has a negative effect on Y. Thus we cannot state what the effect of X on Y is, without knowing whether W is low or high, that is, the value of the variable W. There is no valid bivariate relationship between X and Y that can be stated. The relationship between X and Y is part of a larger causal system involving a trivariate relationship (Donaldson 2001). Much of contingency theory research has studied organizational structure (Lawrence 1993; Donaldson 1995; Donaldson 1996), and this tradition is referred to as structural contingency theory (Pfeffer 1982). The essence of structural contingency theory is that organizational effectiveness results from fitting characteristics of the organization, such as structure, to contingencies that reflect the situation of the organization (Burns and Stalker 1961; Woodward 1965; Lawrence and Lorsch 1967; Pennings 1992). This fit-performance relationship is the heart of the contingency theory paradigm. It provides the theoretical explanation of the two points: the association between contingency and structure, and the contingency change causing structural change. In the structural contingency theory, the relationship is between some characteristic of the organization and effectiveness, and a contingency is defined as any variable that moderates the effect of an organizational characteristic on organizational performance. Thus the contingency factor determines which characteristics produce high levels of effectiveness of the organization (Donaldson 2001).

There are two main applications of contingency theory in IS research. One is the information processing model, and the other is the task-technology fit model. Both are discussed below.

3.2.1 Information Processing Model

While applying contingency theory in information systems research, a large number of organizational theory researchers have made information processing the central concept in certain models. These models attempt to describe how organizations can match information processing requirements arising from uncertainties to information processing capacity arising from organization design and structure, in order to achieve high organizational performance (Galbraith 1973; Tushman and Nadler 1978; Daft and Lengel 1984; Daft and Lengel 1986; Keller 1994). From the information processing view of organization, organizations can be viewed as open social systems which must cope with environmental and organizational based uncertainty. Organizational structure must perform the major functions of facilitating the collection of information from external areas as well as permitting effective processing of information. Organizational effectiveness is a function of the fit between the information requirements and the information processing capacity of the organization (as shown in Figure 3). Too much capacity will be redundant and costly, while too little capacity will not get the job done (Tushman and Nadler 1978).

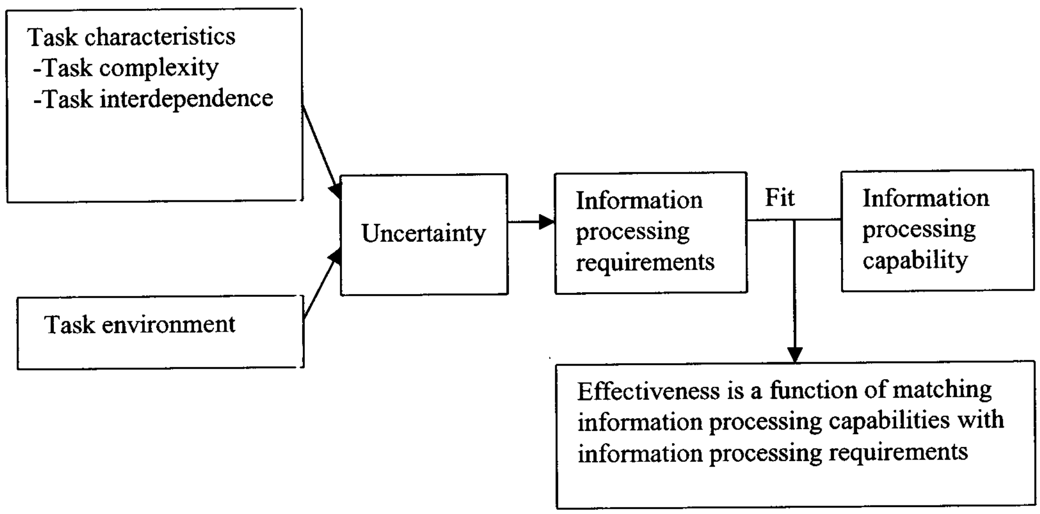

Figure 3: Information Processing Model (Tushman and Nadler 1978)

3.2.1.1 Uncertainty

Uncertainty is the key concept in the information processing model. It is widely accepted that the objective of information systems is to deal with uncertainty (Daft and Lengel 1986). Uncertainty means the absence of information (Miller and Frick 1949; Shannon and Weaver 1949; Garner 1962; Downey and Slocum 1975; Tushman and Nadler 1978). Galbraith (1977) defined uncertainty as "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization" (Galbraith 1973). As information increases, uncertainty decreases.

The amount of information needed to perform the task has a negative relationship with task predictability (Daft and Macintosh 1981).

According to the information processing approach, task uncertainties give rise to information processing needs that should be matched by information processing capacities. Information is needed to reduce uncertainty, and effectiveness depends on capacity to process information and match information processing capacities with the uncertainty that organizations face (Galbraith 1973; Tushman 1978; Tushman and Nadler 1978; Daft and Lengel 1986). In the situation of high uncertainty, preplanning is not possible, so a greater need exists for information related actions on an ongoing basis (Galbraith 1973; Daft and Macintosh 1981; Daft and Lengel 1986). In the situation of high certainty, workers can pre-plan to handle expected tasks and usually do not need to get extra and/or large amounts of information.

There are three distinct sources of work-related uncertainties: task complexity, task interdependence, and task environment (Tushman 1979).

Task complexity means uncertainty (Galbraith 1973; Tushman and Nadler 1978; Weick 1979; Daft and Macintosh 1981). Most studies support the notion that task complexity is associated with greater information needs (Hackman 1968; Hage and Aiken 1969; Hackman and Vidmar 1970; Tushman 1978; Tushman 1979; Van de Ven and Ferry 1980; Daft and Macintosh 1981).

Task interdependence requires coordination (Malone and Crowston 1994). Coordination means integrating or linking different related roles to accomplish a collective set of tasks (Van de Ven et al., 1976). Coordination also means mutual adjustments based upon new information (Thompson 1967). Coordination lends itself well to support from information and communication technologies. When interdependence is high, frequent adjustments are needed, and hence more information must be processed (Van de Ven et al., 1976).

The task environment is defined as those external actors which are attended to by organizational members (Downey and Slocum 1975; Tushman and Nadler 1978). The environment is generally seen as a source of uncertainty, since areas outside the organization are not under control and are therefore potentially unstable (Thompson 1967; Weick 1979).

3.2.2 Task-Technology Fit Model

Another application of contingency theory in information systems research is the task-technology fit model. TTF models take a decidedly rational approach by assuming that users choose to use the type of IT that provides benefits, such as improved job performance, regardless of their attitude toward the IT. The task-technology fit model suggests that information systems should affect performance, depending upon the fit between task requirements and capability of the systems (Goodhue 1995; Zigurs and Buckland 1998). After investigating the link between information technology and individual performance, Goodhue and Thompson (1995) found that utilization and task-technology fit together predicted performance better than each factor alone (Goodhue and Thompson 1995) (as shown in Figure 4). Dishaw and Strong (1998) developed conceptually and tested empirically a model based on Goodhue and Thompson's (1995) task-technology fit construct, to explain the factors that lead to the use of software maintenance support tools. In their empirical study, Dishaw and Strong (1998) showed that a fit between software maintenance tasks and available maintenance support software tools was associated with the actual use of the tools. Task-technology fit explained usage better than task and technology variables alone (Dishaw and Strong 1998).

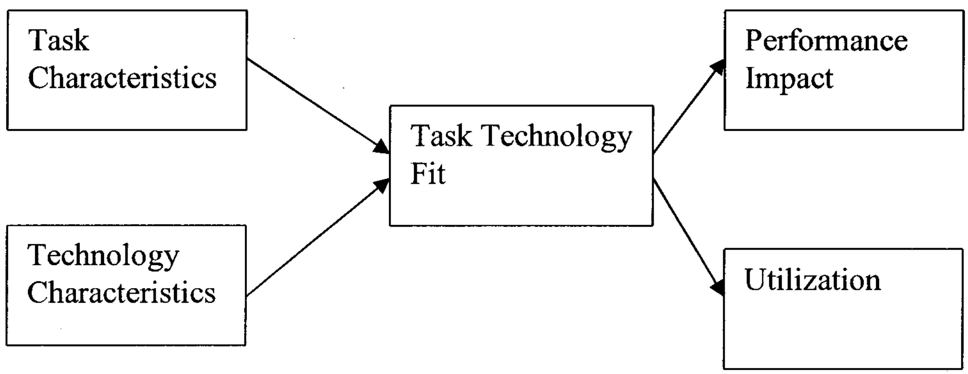

Figure 4: Task Technology Fit Model (Goodhue and Thompson 1995)

While the focus of Goodhue and Thompson's (1995) general theory is on the performance of individual users of information technology, Zigurs and Buckland (1998) proposed a specific theory of task-technology fit that addresses the development and deployment of group support systems to improve group performance (as shown in Figure 5). Zigurs and Buckland's (1998) specific theory of task-technology in the context of group support systems was later tested and largely confirmed by Zigurs et al. (1999), in a review of examples of published group support systems (Zigurs et al., 1999).

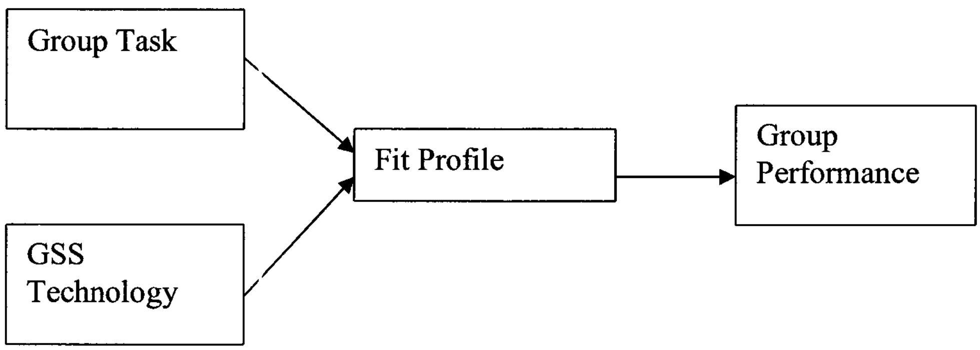

Figure 5: Task Technology Fit for GSS (Zigurs and Buckland 1998; Zigurs et al., 1999)

We summarize the main constructs of the models discussed above in Table 3.

3.2.3 Operational Concepts of Fit

The concept of fit is central to contingency theory. Fit can be conceptualized and tested in a number of different ways. It is important to be very precise in specifying what kind of fit is proposed and how to test that specification with an appropriate method (Schoonhoven 1981; Van de Ven and Drazin 1985; Venkatraman 1989). In contingency theory, three distinct definitions of fit have been identified: fit as congruence, fit as interaction, and fit as internal consistency (Drazin and Ven 1985). These ideas were extended to identify six unique perspectives on fit: fit as matching, fit as covariation (internal consistency), fit as

Table 3: Main Constructs of the Models Used as Theoretical Background in This Study

Theory	Models	Main constructs
Attitude/behavior Theory	Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975)	• Attitude Toward Act or Behavior; • Subjective Norm; • Behavioral Intention; • Behavior.
	Technology Accep tance Model (TAM) (Davis 1989; Ajzen 1991)	• Perceived Usefulness; • Perceived Ease of Use; • Behavioral Intention to Use; • Actual System Use.
	Theory of Planned Behaviour (TPB) (Ajzen 1985; Ajzen 1991)	• Attitude Toward Act or Behavior; • Subjective Norm; • Perceived Behavioral Control; • Behavioral Intention; • Behavior.
	Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003)	• Performance Expectancy; • Effort Expectancy; • Social Influence; • Facilitating Conditions; • Behavioral Intention; • Use Behavior.
Contingency Theory	Information Processing Model (Tushman and Nadler 1978)	• Task complexity; • Task interdependence; • Task environment; • Uncertainty; • Information Processing Requirements; • Information Processing Capability; • Effectiveness of Information Systems.
	Task-Technology Fit (TTF) (Goodhue and Thompson 1995)	• Task characteristics; • Technology Characteristics; • Task-Technology Fit; • Utilization; • Performance Impacts
	Task-Technology Fit (TTF) (Zigurs and Buckland 1998; Zigurs, Buckland et al. 1999)	• Group Task; • GSS Technology; • Fit Profile; • Group Performance.

gestalts (internal congruence), fit as moderation (interaction), fit as mediation (intervention), and fit as profile deviation (adhere to a specified profile).

These perspectives vary in their degree of specificity of the theoretical relationship between variables, in the number of variables in the fit relationships, and in whether the concept of fit is anchored to a particular criterion variable (Venkatraman 1989). The first three conceptualizations of fit are criterion-free, i.e., they have universal applicability and are not anchored to any particular dependent variable, such as effectiveness. Since the purpose of the study of fit in the information systems area is to examine the relationship between fit and performance impact, these three conceptualizations are not suitable (Nidumolu 1996).

Three main operational concepts of fit are used in the literature: fit as congruence, fit as interaction (Pennings 1987), and fit as absolute difference. The definitions of the three operational concepts are summarized in Table 4. The concept of fit as congruence is the above mentioned "fit as profile deviation". The operational concept of fit as congruence holds that fit is a combination of the levels of contingency and structure that produce higher performance. Other combinations are incongruent so that the level of the structure does not fit that required by the level of the contingency and hence lower performance results (i.e., lower performance than in fit). There is some line of fit, which may be curvilinear or linear. This is the line that connects all the points of fit. For each level of the contingency variable there is a level of the organizational structural variable that is the fit (i.e., yields the highest performance). Deviation from this fit line constitutes misfit and so produces lower performance. This idea can be taken farther by conceptualizing degrees of misfit. The farther the organization is away from fit, the greater is its misfit and the lower is its resulting performance expected to be. The concept of fit as congruence is used in the studies of Zigurs and Buckland (1998) and Zigurs et al. (1999).

There is a second operational definition of the fit concept in the literature. This is fit as an interaction between the contingency and the organizational structural variable. Specifically, fit is measured by a multiplicative interaction term, that is, the contingency variable multiplied by the organizational structure variable (Schoonhoven 1981). This corresponds to Venkatraman's (1989) conceptualization of fit as moderation and Van de Ven and Drazin's (1985) interaction approach. The concept of fit as interaction is used by Goodhue (1995) and Dishaw and Strong (1998). However there are many problems in operationalizing fit as an interaction term (Donaldson 2001). First, a multiple interaction term does not capture the relationship between congruence (fit) and performance. Another issue is that the multiplicative interaction term assumes that the fit is a straight line. However, some of the fits are not linear, but are curvilinear. Thus the multiplicative interaction term is not a correct operationalization of the fit construct. An interaction term tells us something that may be of interest, but conceptually it does not have the meaning of fit that has existed in contingency theory research.

The third operational definition of fit is fit as absolute difference. It was developed by Alexander and Randolph (1985) and has been used by David et al. (1989), Keller (1994), and Lai (1999). With this approach, fit is defined as the absolute difference between the values of technologies and task characteristic variables, i.e., fit = | technology variable – task variable |. The approach assumes that for each value of a technology characteristic, there is a best value of matching task characteristic that results in high performance.

Researchers wishing to study fit in the sense that has been meant in contingency theory research should use congruence measures, not the interaction term. Therefore it is preferable to use the concept of fit as congruence rather than conception of fit as interaction (Donaldson 2001). This study will use the concept of fit as congruence. The concept of fit as congruence must identify the ideal fit profile. That is, in each situation what kind of mobile work support can lead to perceived performance improvement.

Table 4: Operational Concepts of Fit

	Operation of fit	Studies used
Congruence	Fit is a combination of the levels of the contingency and structure that produce higher performance (Drazin and Ven 1985).	Zigurs and Buckland (1998); Zigurs et al. (1999)
Interaction	Fit is measured by a multiplicative interaction term, that is, the contingency variable multiplied by the organizational structure variable (Schoonhoven 1981).	Goodhue (1995); Dishaw and Strong (1998)
Absolute difference	Fit is defined as the absolute difference between the values of technologies and task characteristics variables (Alexander and Randolph 1985).	Alexander and Randolph (1985); David et al. (1989); Keller (1994); Lai (1999)

There are two conceptualization methods for the fit as congruence: the subjective method, and the objective method (Junglas 2003).

3.2.4 Two Fit Conceptualizations for the Fit as Congruence: Subjective and Objective

In general, two conceivable fit conceptualizations exist (Junglas 2003): a subjective and an objective conceptualization of fit. The objective form of fit is sometimes referred to as "engineering fit" (Nance and Straub 1996) whereas the subjective form of fit is called "tool fit" (Davern 1996).

Taking a subjective stance means measuring fit from a user's perspective. Users that utilize a technology because of its instrumentality in their task are believed to be capable of evaluating that technology's fit from their personal experience. That is, users will give evaluations based on the extent to which they perceive the system meets their needs and abilities. In this case, user evaluations serve as surrogates for task-technology fit (Goodhue 1995).

Taking an objective stance of fit means determining fit from an external position, i.e., fit is not determined by system users, but by system builders. Any software development can serve as an example. When developing an application, system specifications are always designed in such a way that they match the task that the application is expected to solve, with user characteristics. In this case, fit is measured by system specifications.

This study will use the subjective conceptualization method. The subjective conceptualization method can be further classified into two types: One is facets-of-fit; the other is predicted-outcome.

3.2.5 Two Types of Subjective Conceptualization of Fit

There are two ways of assessing task-technology fit: facets-of-fit or predicted outcomes (Staples and Seddon 2004). If the facets of task technology fit are correctly identified, both measures should be highly correlated. Facets-of-fit is used to identify important facets of the task requirements and to assess whether the proposed tool, in the hands of the intended user, meets each of these facet-of-fit requirements. The other is to predict the outcomes of tool use, again in the hands of the intended user, and see if they are as desired. This is called the predicted-outcomes approach. The facet-of-fit approach to assessing fit would involve asking whether certain key facets of the task requirements are met. By contrast, the predicted-outcomes approach to assessing task-technology fit asks: "Would this toolset, in the hands of this user, lead to the desired outcome?" To answer this question, the respondent imagines using the toolset and attempts to predict the outcome. From this perspective, Davis' (1989) famous questionnaire on perceived usefulness is a predicted-outcomes measure. Goodhue and Thompson's (1995) task technology fit instrument is a facets-of-fit measure.

This study will use the predicted outcome method to assess the fit. We summarize studies that used different methods of conceptualization of fit in Table 5.

Table 5: Methods of Conceptualization of Fit in Existing Literature

Author(s)	Study	Method of conceptualization of fit
Goodhue and Thompson (1995)	Task-Technology Fit and Individual Performance	Subjective conceptualization of fit - Facets-of-fit
Goodhue (1995)	Understanding User Evaluations of Information Systems	Subjective conceptualization of fit - Facets-of-fit
Dishaw and Strong (1998)	Assessing Software Maintenance Tool Utilization Using Task-technology Fit and Fitness-for-Use Models	Subjective conceptualization of fit - Facets-of-fit
Ferratt and Vlahos (1998)	An Investigation of Task-Technology Fit for Managers in Greece and the US	Subjective conceptualization of fit - Facets-of-fit
Goodhue et al. (2001)	User Evaluation of IS as Surrogates for Objective Performance	Subjective conceptualization of fit - Facets-of-fit
Gebauer and Shaw (2004)	Success Factors and Impacts of Mobile Business Applications: Results from a Mobile e-Procurement Study	Subjective conceptualization of fit - Predicted outcomes
Lee et al. (2004)	Analysis of Mobile Commerce Performance by Using the Task-Technology Fit	Subjective conceptualization of fit - Predicted outcomes
Staples and Seddon (2004)	Testing the Technology-to-Performance Chain Model	Subjective conceptualization of fit - Both Facets-of-fit and Predicted outcomes
Zigurs and Buckland (1998)	A Theory of Task/Technology Fit and Group Support Systems Effectiveness	Objective conceptualization of fit
Zigurs et al. (1999)	A Test of Task-Technology Fit Theory for Group Support Systems	Objective conceptualization of fit

Table 5: Methods of Conceptualization of Fit in the Literature (Cont.)

Author(s)	Study	Method of conceptualization of fit
Kim et al. (1998)	Utilization and User Satisfaction in End-User Computing: A Task Contingent Model	Fit as interaction
Mathieson and Keil (1998)	Beyond the Interface: Ease of Use and Task/Technology Fit	Fit as interaction
Dishaw and Strong (1999)	Extending the Technology Acceptance Model with Task-Technology Fit Constructs	Fit as interaction
Anandarajan and Arinze (1998)	Matching Client/Server Processing Architectures with Information Processing Requirements: A Contingency Study	Fit as interaction
Dishaw and Strong (1998)	Supporting Software Maintenance with Software Engineering Tools: A Computed Task-Technology Fit Analysis	Fit as interaction
Alexander and Randolph (1985)	The Fit between Technology and Structure as a Predictor of Performance in Nursing Subunits	Fit as absolute difference
Keller (1994)	Technology-Information Processing Fit and the Performance of R&D Project Groups: A Test of Contingency Theory	Fit as absolute difference
Lai (1999)	A Contingency Examination of CASE-task Fit on Software Developer's Performance	Fit as absolute difference

3.3 Integrating Contingency Theory with Attitude/behavior Theory

Both aspects, attitude toward IT in attitude/behavior theory and rationally determined expected consequences from using IT in contingency, are likely to affect user choices to utilize IT. That is, combining the two models is likely to provide a better explanation of IT utilization than either an attitude or a fit model could provide separately. Goodhue and Thompson's (1995) technology-to-performance chain model combined insights from research on user attitudes as predictors of utilization and insights from research on task-technology-fit as a predictor of performance (as shown in Figure 6). The basic argument of the model is that, for an information technology to have a positive impact on individual performance, the technology must fit with the tasks it is supposed to support and for which it has to be used (Goodhue and Thompson 1995). Dishaw and Strong (1999) also combine TAM and TTF to propose an integrated model (Dishaw and Strong 1999).

Goodhue and Thompson's (1995) technology-to-performance chain model was tested by Staples and Seddon (2004). Based on Goodhue and Thompson's (1995) technology-to-performance chain model, Junglas and Watson (2003) also proposed an integrated model (as shown in Figure 7).

3.3.1 Are Perceived Usefulness and Task Technology Fit the Same Constructs or Different Constructs?

We argue that the concepts of perceived usefulness and performance expectancy are identical with the concept of task-technology fit. They are just in different kinds of perspectives.

The definition of perceived usefulness in TAM (the degree to which a person believes that using a particular system would enhance his or her job performance (Davis 1989)) can be compared with the definition of performance expectancy in the Unified Theory of Acceptance and Use of Technology (UTAUT) (the degree

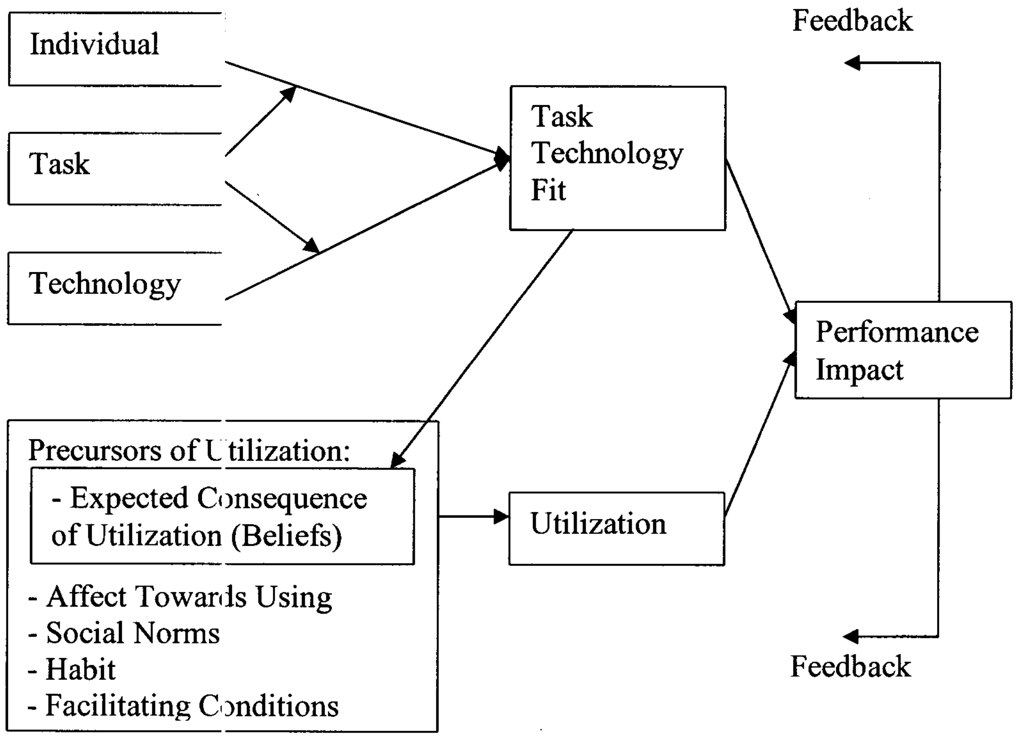

Figure 6: The Technology-to-Performance Chain (Goodhue and Thompson 1995)

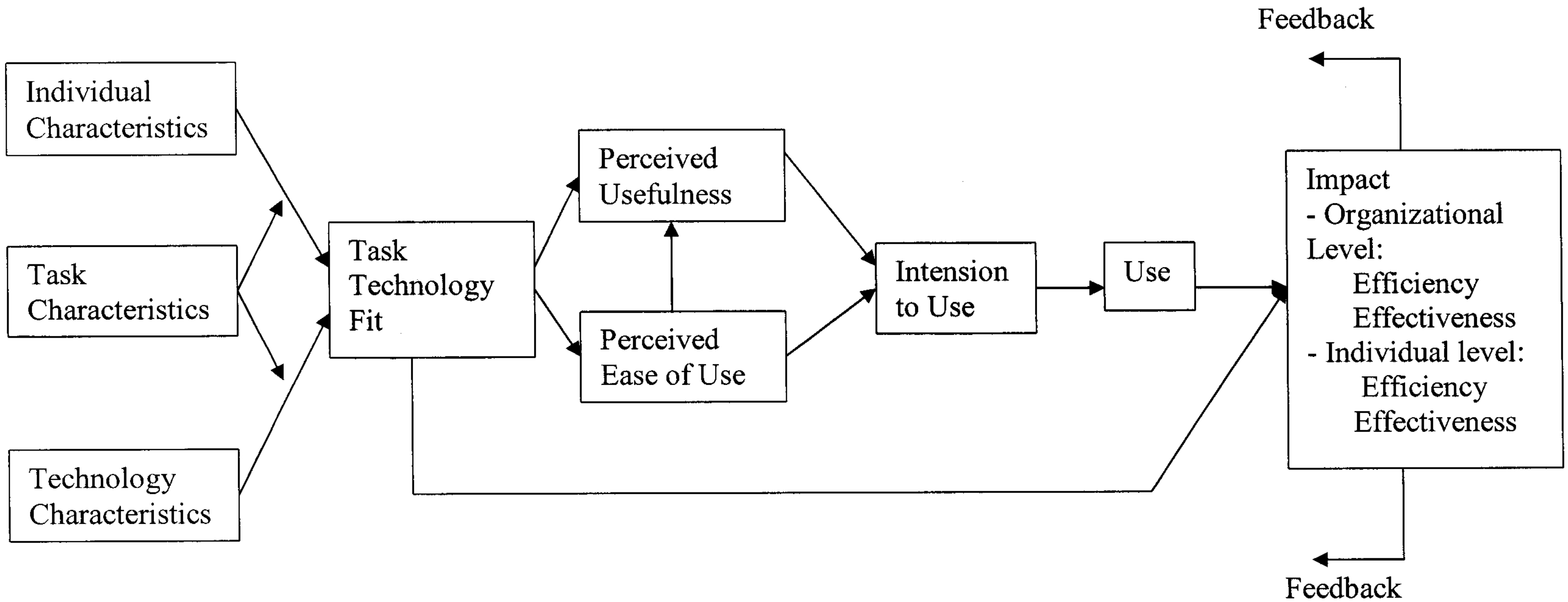

Figure 7: Integrated Model (Integrating TAM and TTF) (Junglas and Watson 2003)

to which an individual believes that using the system will help him or her to attain gains in job performance (Venkatesh, Morris et al. 2003)). Fit is a combination of the levels of the contingency and structure that produce higher performance (Venkatraman 1989). Goodhue and Thompson (1995) define task technology fit as the correspondence between task requirement, individual abilities, and the functionality of the technology (Goodhue and Thompson 1995). Zigurs and Buckland (1998) define task technology fit (for GSS) as ideal profiles composed of an internally consistent set of task contingencies and GSS elements that affect group performance (Zigurs and Buckland 1998). To conclude, in IS research, fit is the combination of technology and task that produces higher performance.

The argument that task technology fit and perceived usefulness are the same construct is supported by Staples and Seddon (2004) and Dishaw and Strong (1998). Staples and Seddon (2004) contended that Davis's (1989) perceived usefulness is conceptualization of fit as predicted-outcomes, while Goodhue's (1995) task-technology fit instrument is conceptualization of fit as facets-of-fit. Dishaw and Strong (1998) contended that Goodhue's (1995) task-technology fit instrument (i.e., conceptualization of fit as facets-of-fit) and fitness for use (i.e., conceptualization of fit as predicted-outcomes) are just differently derived operationalizations of a single fit construct (Dishaw and Strong 1998).

There are some studies that have viewed Goodhue's (1995) task-technology fit and Davis's (1989) perceived usefulness as the same construct. Garrity and Sanders (1998) mixed Davis's (1989) perceived usefulness and Goodhue's (1995) task-technology-fit instruments to measure the success of information systems (Garrity and Sanders 1998). Lee et al. (2004) also use perceived usefulness as the measurement of task-technology fit (Lee et al., 2004).

Combining contingency theory and attitude/behavior theory, we propose the research model in the next chapter.

Chapter 4: Research Model

The main objective of this study is to identify the ideal fit between the characteristics of mobile tasks and mobile technology work support functionalities. In this study, fit is defined as the congruence between task characteristics and the functionality of the technology that improves work performance. We will analyze task characteristics along the dimensions of 1) task complexity, 2) task interdependence, 3) time criticality, and 4) location sensitivity. For mobile work support functions, we examine six typical applications: 1) mobile communication including voice communication, text messaging, and mobile notification, 2) mobile information searching, 3) mobile transaction processing, both offline and online, 4) mobile job dispatching, including batch mode and real time, 5) location-related services including location tracking and navigation, and 6) mobile office. We will analyze the fit between the four dimensions of mobile task characteristics and the six typical mobile work support applications. The perceived ideal fit should then lead to intention to use. The research model is illustrated in Figure 8. As we discussed earlier, fit is measured by perceived usefulness. We represent the research model with the associated path between task characteristics and the perceived usefulness of mobile technology functionalities in Figure 9.

4.1 Mobile Task Model

A task is defined as an activity the task doer performs in order to accomplish a goal (Vakkari 2003). We analyze the task characteristics of mobile work along four dimensions: task complexity, task interdependence, time criticality, and location sensitivity.

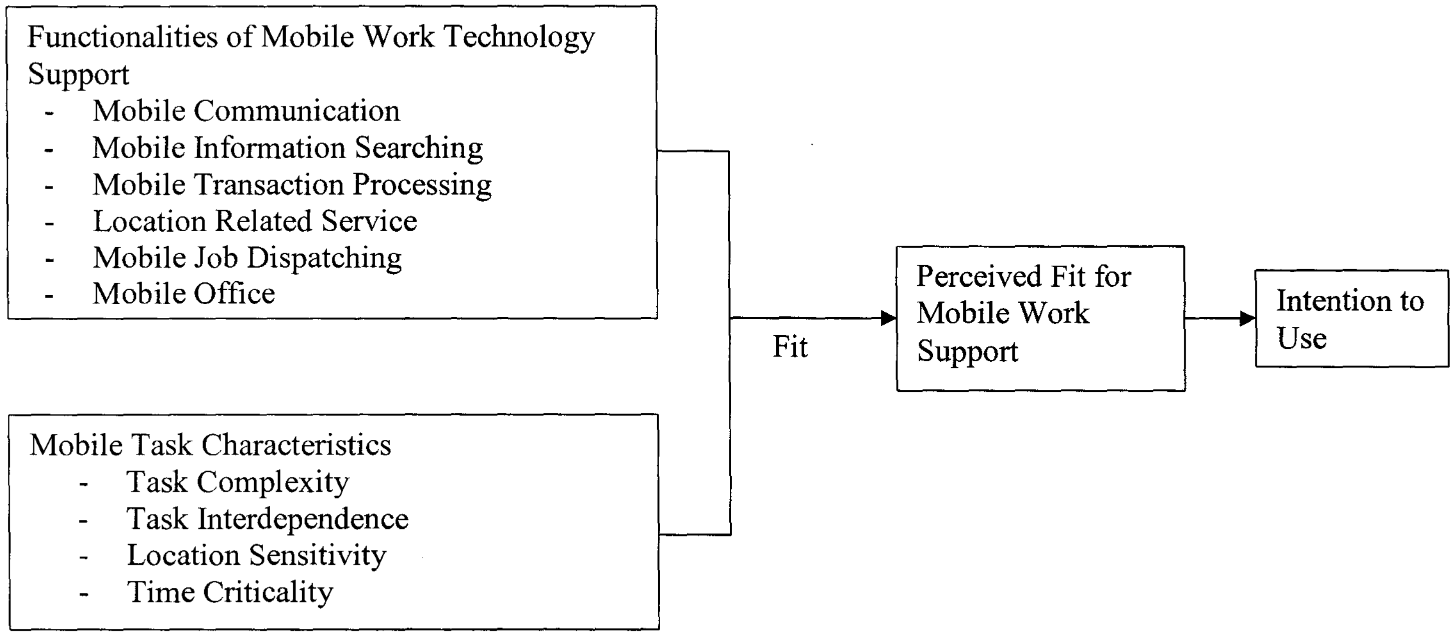

Figure 8: Research Model

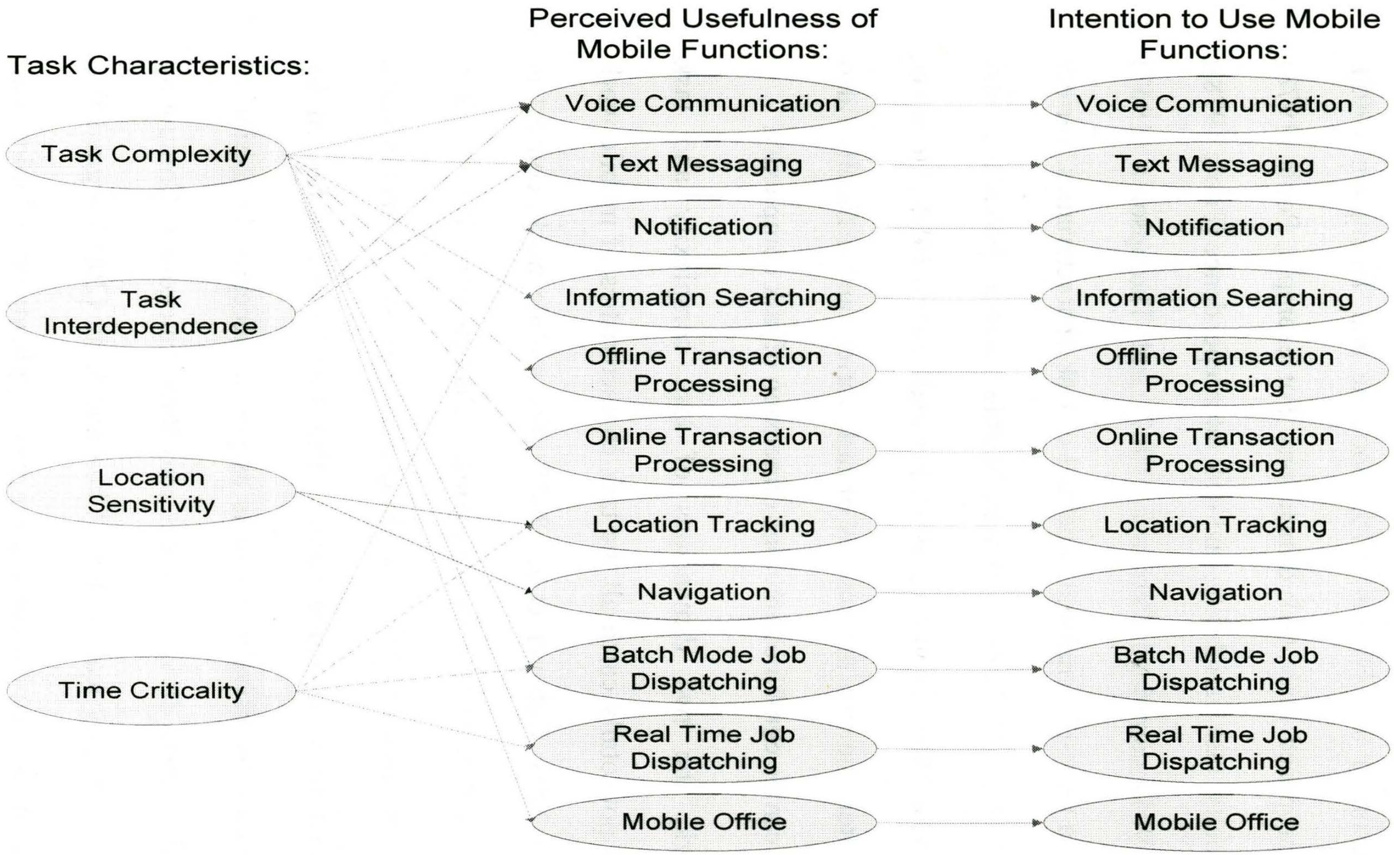

Figure 9: Research Model with Associated Paths Between Task Characteristics and Perceived Usefulness of Mobile Technology Functionalities

Tasks are usually analyzed along the dimensions of task complexity and task interdependence (Tushman and Nadler 1978; Goodhue and Thompson 1995). Some studies have proposed three task dimensions. For example, Poole (1978) suggested: task difficulty, task variability, and task interdependence (Poole 1978). Fry and Slocum (1984) combined Perrow's (1967) and Thompson's (1967) dimensions to create a three-dimensional construct of task characteristics: variety (number of exceptions), difficulty (non-analyzable search behavior) and interdependence (Perrow 1967; Thompson 1967; Fry and Slocum 1984). However, as we will discuss later, the two dimensions of task variety and difficulty (also called analyzability) can be combined into one dimension of task complexity.

For mobile work, the two dimensions of task complexity and task interdependence can not totally catch all the task characteristics of mobile work (Junglas and Watson 2003; Gebauer et al., 2005). For mobile work, context in which the tasks are performed is a very important characteristic. It is the key characteristic that distinguishes mobile work from stationary work. Any activities are inherently situated in a particular context that frames and is framed by performing the activities recursively. There is as yet no accepted definition of context. Schilit et al. (1994) divides context into three categories: Computing context, user context, and physical context. Chen and Kotz (2000) argued that time is also an important and natural context for many applications. Schmidt et al. (1999) define context as knowledge about the user's and IT device's state, including surroundings, situation and, to a lesser extent, location. Dey defines context as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves" (Dey and Abowd 2000; Dey 2001). They contend that combining several context values may generate a more powerful understanding of the current situation. "Primary" contexts, including location, entity, activity, and time, act as indices into other sources of contextual information (Dey and Abowd 2000). Abowd and Mynatt (2000) argue that although a complete definition of context is elusive, the "five W's" of context are a good minimal set of necessary context: who is using the system; what the system is being used for; where the system is being used; when the system is being used; and why the system is being used (Abowd and Mynatt 2000).

In this study, the context of mobile work is defined as the circumstances in which mobile tasks are being carried out by mobile workers. From the definitions of context we find that time and location are the two fundamental elements for context. Ohta (1993) has noted, "If time is the warp of economics, then space is its woof" (Ohta 1993). Balasubramanian et al. (2002) consider jointly mapping a specific activity in terms of the degree to which the activity is constrained (or flexible) spatially and the degree to which the activity is constrained (or flexible) temporally (Balasubramanian et al., 2002). Junglas and Watson (2003) propose the dimensions of time-dependent and location-dependent to describe mobile task. Gebauer et al. (2005) introduce the concept of time criticality. This study uses the two dimensions of time criticality and location sensitivity to describe the context characteristics of mobile work. Of course, context includes more than time criticality and location sensitivity.

The four dimensions of the task model are presented in Table 6 and discussed in detail as follows.

Table 6: Four Dimensions of the Task Model

Task Dimension	Definition
Task complexity	The degree of non-routinization and non-repetitiveness of the task being performed
Task interdependence	The extent to which workers depend upon each other to accomplish their tasks
Time criticality	The degree of how time is critical to the performing of the task
Location sensitivity	To what extent the performing of the task is dependent on the location-related information.

4.1.1 Task complexity

Task complexity means the degree of routinization and repetitiveness of the task performance. The concept of task complexity is frequently used to differentiate tasks in organizational studies, information science, and psychology (Bystrom 1999). In the literature, there are three main definitions of task complexity.

The first is Campbell's (1988) integrative framework for task complexity. He relates task complexity directly to the task attributes that increase information load, diversity, or rate of change. He claims that complexity can be defined objectively, independent of particular task doers. He concludes that these three information-processing factors can also capture the cognitive demands experienced by task doers. The framework consists of four basic task characteristics that meet the requirements of information load, diversity, and change: (1) multiple paths indicate the number of possible ways of arriving at a desired outcome, (2) multiple outcomes, (3) conflicting interdependence among paths, and (4) uncertain linkages between potential path activities and desired outcomes. By combining these characteristics, Campbell creates a typology of complex tasks. Based on the typology, he classifies tasks into simple, decision, judgment, and problem tasks (Campell 1988). This classification was used by Zigurs and Buckland (1998) as the basis to explore the relations between task/technology fit and GSS (Group Support System) effectives. However, this definition of task complexity is not relevant to mobile work tasks.

The second is the definition of the concept of task complexity by Bystrom (1999), Bystrom and Jarvelin (1995), and Tiamiyu (1992). In their studies, task complexity is assumed to depend on the degree of uncertainty associated with the inputs (including information), the procedures for performing the task, and the outcomes of the task (based on the work of Van de and Ferry (1980)) (Tiamiyu 1992; Bystrom and Jarvelin 1995; Bystrom 1999). Task complexity is seen as resulting from experienced uncertainty produced by incomplete a priori knowledge about inputs, procedures, and outcomes of the task at hand. This knowledge is termed as pre-determinability by Bystrom and Jarvelin (1995). They divide task complexity into five subcategories (Bystrom and Jarvelin 1995):

(1) Automatic information processing tasks are a priori completely determinable so that, in principle, they could be automated - whether actually automated or not.

(2) Normal information processing tasks are almost completely a priori determinable, but require some case-based consideration concerning.

(3) Normal decision tasks are still quite structured, with case-based consideration having a major role.

(4) Known, genuine decision tasks: the type and structure of the result is known a priori, but permanent procedures for performing the tasks have not yet emerged. Thus, the process is largely indeterminable, and so are its information requirements.

(5) Genuine decision tasks are unexpected, new, and unstructured. Neither the result, the process, nor the information requirements can be characterized in advance.

The degree of task complexity increases when moving from category 1 to 5.

The third is the definition of task complexity in organizational studies. They differentiate task complexity into two components: task variety and task analyzability (Zeffane and Gul 1993). The distinction is based on the work of Daft and Macintosh (1981). Task variety refers to the frequency of unexpected and novel events that occur in work processes (Perrow 1967; Daft and Macintosh 1981; Fry and Slocum 1984). For Thompson (1967), Hickson et al. (1969), and Woodward (1965), task variety was measured as the stability and uniformity of inputs and outputs (Woodward 1965; Thompson 1967; Hickson et al., 1969). Task variety has also been measured as the routinization, repetitiveness, stability, or rigidity of the work (Litwak 1961; Hage and Aiken 1969). Galbraith (1973) uses the term "predictability" to refer to the same concept of variety. He suggests that tasks differ in their amount of predictability and thus, in the amount of uncertainty which the organization must deal with during task execution (Galbraith 1973). Low variety means that workers experience considerable certainty about the occurrence of future activities, high variety means that workers typically cannot predict problems or activities in advance (Vakkari 1998). Analyzability is concerned with how workers respond to problems that arise. It refers to the degree of how the process of dealing with exceptions is analyzable once they are encountered (Perrow 1967). When the work process is analyzable, workers typically follow objective and known procedures to deal with problems. If the work is not analyzable, no computational procedures can be found for solving problems. Workers have to search for solutions themselves (Fry and Slocum 1984; Vakkari 1998). Actually, the two dimensions of variety and difficulty might tend to be correlated in practice, so they might be combined into a single dimension (Perrow 1967). Work by Van de Ven and Delbecq (1974) supports the notion that it is often difficult to tease out these two separate dimensions in practice (Van de Ven and Delbecq 1974). Thus it's better to consider task complexity as one concept other than two separate dimensions of variety and analyzability (Tushman and Nadler 1978; Goodhue and Thompson 1995).

In fact, the second and third concepts of task complexity are highly consistent. When the information requirements, procedures, and outcomes of a task are difficult to anticipate, the workers face unexpected and novel events that they cannot predict in advance, and the process does not follow any known procedures. The pre-determinability of a task's input, process, and output, affects task variety and task analyzability to a great extent (Vakkari 1998). In this study, the definition of task complexity will be based on the two concepts of task complexity; that is, task complexity is the degree of non-routinization and non-repetitiveness of the task being performed.

4.1.2 Task Interdependence

There are four types of task interdependence: pooled interdependence, sequential interdependence, reciprocal interdependence, and team work. The first three types of interdependence were identified by Thompson (1967), while Van De Ven et al. (1976) added the fourth type team work. Pooled interdependence exists when the task completion of one worker is not directly contingent upon others, but it is impacted by the performance of all others based upon their shared fate as members of the larger collective. In these cases frequent communication is unnecessary for task completion, and activity coordination can be regulated through establishing regular standard procedures. Sequential interdependence occurs when the task completion of one worker relies upon others. In sequential interdependence, interactions occur in a certain order, in which the outputs of one worker become the inputs of another (Hackathorn and Keen 1981). In reciprocal interdependence there is a bi-directional flow, and the outputs of each worker may become inputs for others. Because this process is continuous, the nature of the communication patterns is similarly dynamic. Consequently, standardization and planning are ineffective means to coordinate behaviors. Instead, Thompson suggests coordination by mutual adjustment in these situations, which "involves the transmission of new information during the process of action" (Thompson 1967). Team work flow refers to situations where the work is undertaken jointly by workers who collaborate in order to complete the work. There is no measurable temporal lapse in the flow of work between members, as there is in the sequential and reciprocal cases; the work is acted upon jointly and simultaneously by workers at the same point in time (Van de Ven et al., 1976). There exists a hierarchical relationship between the types of task interdependence: pooled must exist before sequential, sequential must exist before reciprocal forms of interdependence, and reciprocal interdependence must exist before team work (Thompson 1967; Van de Ven et al., 1976). In this study task interdependence is defined as the extent to which workers depend upon each other to accomplish their tasks (Thompson 1967; Fry and Slocum 1984).

4.1.3 Time Criticality

Time is an essential feature of social and organizational life (Whipp et al., 2002), and is a resource that is consumed by activities (Hassard 1996). Time is a way of locating human behavior, a mode of fixing the action that is particularly appropriate to circumstances (Moore 1963). Time is a scarce resource, and its scarcity enhances its worth (Hassard 1996). Lakoff and Johnson put forward three metaphors for time: time is money; time is limited resource; time is a valuable commodity (Lakoff and Johnson 1980). Time control is a central task for management. In management, time has been closely related to productivity. An organization is considered more productive or efficient when it shortens the period of time it takes to accomplish a given amount of work (Lee and Liebenau 1999).

People in organizations experience time through the shared temporal structures they enact in their working practices. Whether implicitly or explicitly, people make sense of, regulate, coordinate, and account for their activities through the temporal structures they enact. Like social structures in general (Giddens 1984), temporal structures simultaneously constrain and enable activities. According to Hassard (1996), temporal structuring is at the heart of organization and therefore temporal factors should be of primary concern for an organization. The neglect of temporality may hinder our understanding of information and communication technology used in organizations (Lee and Liebenau 2000).

For mobile work, the temporal structure is greatly affected by location. Time and space are always interlinked - changes in space provoke changes in time (Giddens 1990). Social geographers (Hagerstrand 1975; Carlstein 1982) have developed a time geography approach to analyze human actions across time-space. Time geography perceives time and space as inseparable and makes considerable effort to understand social phenomena in terms of a "time-space ecology" (Hagerstrand 1975). This approach looks at the context in which human activities are carried on, tracing how this influences (and is influenced by) the daily movements or paths of human agents and groups. This approach pays particular attention to the source of constraints over human activities deriving from the physical properties of bodies and their social context. In order to analyze human activities across time and space, time geographers use dynamic "time-space maps" to represent these daily paths and the overall "boundaries" limiting behavior across time-space provided by these constraints. Individual activities often are associated with certain locales. Carlstein (1982) illustrates this using a concept of "packing" of "bundles" of time consuming activities of different sizes and durations into a group time budget. Due to the mobility characteristics of mobile work, the temporal structure of mobile work is irregular, while the temporal structure of stationary work is regular. As shown in Figure 10 the temporal structure of stationary work is linear, while the temporal structure of mobile work is broken and various.

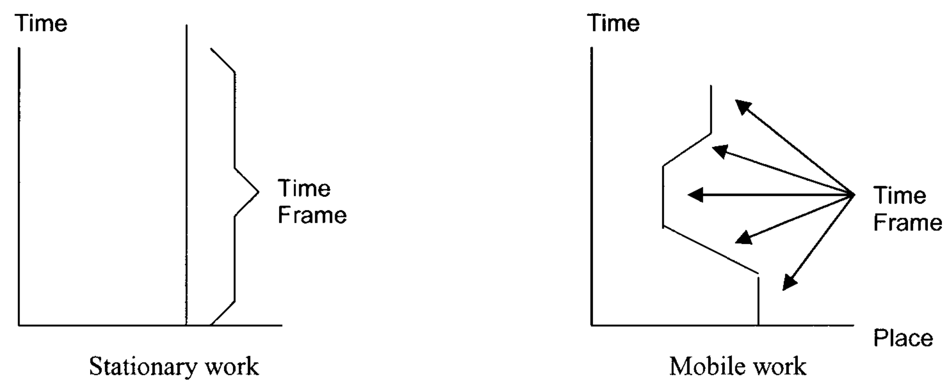

Figure 10: Temporal Structure

There have been some studies that address the dimensions of temporal structures, or temporality. Zerubavel (1981) delineated four major dimensions of the temporal profile of any situation or event: sequential structure, duration, temporal location, and rate of recurrence. The sequential structure refers to the ordering of situations and events. It is in the nature of many events, activities, and situations that they cannot all take place simultaneously and must, therefore, be temporally segregated from one another in terms of 'before' and 'after'. The sequential order in which events are arranged may sometimes be purely random. However, it is very often the case that it is rigid in the sense that events are not reversible. The duration concerns how long situations and events last. Numerous events in social life have a relatively fixed duration on a regular basis. Most of the timetables and schedules we use would not be possible without the relatively rigid duration of events and activities in our daily life. Temporal location is concerned with when situations and events take place. Locating an event at a particular point over the continuum of time is the basis of scheduling, by which we routinely fix events and activities at particular prearranged points in time - at particular hours, on particular days of the week, and in particular months of the year. In general, most routine daily activities are scheduled in a fairly rigid manner for particular times of the day and for particular days of the week. Fixing the temporal location of events entails the norm of "punctuality", which assigns a normative character to the acts of being "early" or "late". The rate of recurrence is concerned with how often situations and events take place. When they occur repeatedly and regularly, they entail rhythms or cycles (Zerubavel 1981).

An instrument to measure temporal norms developed by Schriber (1986) and Schriber and Gutek (1987) consists of the following dimensions: Allocation, Scheduling, Sequencing, Deadline, Punctuality, Pace, Temporal buffers, and Autonomy (Schriber 1986; Schriber and Gutek 1987). Allocation is the amount of time, whether planned or expended, devoted to a task or activity, regardless of when the amount occurs. This is primarily concerned with size or amount and is based on a conventional standard of measurement (e.g., hours or minutes). Scheduling concerns the location of activities and tasks in the temporal realm (e.g., a meeting at 10 a.m.). The temporal boundaries provided by scheduling can be further defined in terms of sequence, deadlines, punctuality, pace, and buffers. Sequencing is at the heart of the concept of scheduling. It refers to "actions following one another in a prescribed order" (Moore 1963). Deadline is also implicit in the concept of scheduling. Deadlines are temporal start and stop points, and can be external or internal to the task, or both. Punctuality is the degree of rigidity to which deadlines are adhered. Some deadlines require tasks to be completed on a certain day, others require completion by a certain hour of a specified day, and still others require completion by an identified minute of a particular hour. Pace is the rate at which activities can be accomplished. It is a measure of the speed of activity or the number of activities that can be done within a given interval of time. Allocation, scheduling and deadlines depend on pace. Temporal buffers are unspecified amounts of time that are built into schedules to allow for the uncertainty in the estimated duration to accomplish a task. The necessity of buffers is evident in lags and delays, and they provide organizations with temporal elasticity. Autonomy is the amount of freedom the job holder has in setting schedules for the completion of his or her tasks over time. It measures the degree to which respondents perceive autonomy over the use of their time.

Based on the work of Zerubavel (1981), Schriber (1986) and Schriber and Gutek (1987), Lee and Liebenau identified six dimensions of temporality: duration, sequence, temporal location, deadline, cycle and rhythm. "Duration" is concerned with the amount of time spent to complete a task or activity. "Temporal location" concerns when activities take place. "Sequence" refers to the order in which activities and tasks take place. "Deadline" refers to the fixed time by when work is to be done. "Cycle" means the periodic regularity in which work is completed repeatedly. "Rhythm" refers to the alteration in the intensity of being busy (Lee and Liebenau 2000).

In this study, we will use the concept of time criticality, which refers to the degree of how time is critical to the performing of the task (Gebauer et al., 2005). Borrowing Lee and Liebenau's (2000) work on the dimensions of temporality, we analyze the time criticality of mobile work along the three dimensions of time window, the degree of on-time, and the degree of urgency. The concept of time window is the same as the "duration" in Lee and Liebenau's (2000) study. That is, the amount of time spent to complete a task or activity at a specific location. Different locations construct different time windows. The time window for mobile work is narrower than stationary work. The degree of on-time means to what extent the mobile tasks must be performed on time. It corresponds to the time dimension of "temporal location" in Lee and Liebenau's (2000) study and the "punctuality" in Zerubavel (1981). The degree of urgency refers to the importance with which a task needs to be performed promptly (urgency) (Gebauer et al., 2005). It also corresponds to the time dimension of "deadline" in Lee and Liebenau's (2000) study.

4.1.4 Location Sensitivity

Mobility makes us think automatically about location. The very idea of "mobility" demands an understanding of location, and the location information may be exploited as a means of understanding the overall mobile context (Dix et al., 2000). Some work can be independent of any particular geographic location. It may be performed from different places over time, or even while moving around. The performing of the tasks is not dependent on dynamic location related information and familiarity with locations. The amalgamation of information and communication technologies help realize the vision of access to information and services "anytime" and "anywhere", hence people should be able to carry out their computational or communicatory activities independently of the hour of the day - i.e., anytime - as well as doing so not being confined to a specific spatial location - i.e., anywhere (Kleinrock 1995; Kleinrock 1996). The notion of "anytime, anywhere" is one of the major premises of mobile technology, in that it promises to remove the bonds between a person's location in space and that person's information and communication resources (Perry et al., 2001). That is, the mobile workers gain freedom through mobile technology support.

However, not all activities are affected by mobile technologies (Balasubramanian et al., 2002). Often the location is the reason for being on the move. Wiberg and Ljungberg's (1999) ethnographic study of mobile telecommunication engineers shows that mobile work often has places of non-negotiable importance. That is, travel could not easily be avoided; you cannot reframe the earth by putting away distance (Wiberg and Ljungberg 1999). Some work is very much sensitive to location related information. For example, field service workers have to go to customer locations to perform the work. Dynamic location related information is critical for job schedule and dispatching of field service work. The familiarity of location may greatly affect field service. Thus field service work is highly location sensitive.

In this study, we propose the concept of location sensitivity to reflect the location characteristics of mobile work. Location sensitivity means to what extent the performing of the task is dependent on location-related information. It can be viewed from two aspects: location variety and location dependence. Location variety means to what extent the mobile workers work at various locations. Low location variety means the task must be performed at a specific location, and workers have less freedom in choosing the working location. Location dependence means to what extent the dynamic location-related information is required to perform the task (Junglas and Watson 2003). The two aspects of location sensitivity are presented in Table 7.

Table 7: Three Aspects of Location Sensitivity

Aspect	Definition
Location variety	To what extent mobile workers work at various locations.
Location dependence	To what extent dynamic location-related information is required to perform the task

4.2 Mobile Work Technology Support

Technology is viewed as human-made advancements that increase the effectiveness and efficiency of specific tasks (Good and Schultz 2000). Mobile technologies can be seen as new resources for accomplishing various everyday activities that are carried out on the move (Tamminen and Oulasvirta 2004).

We should clarify that "wireless" and "mobile" are two different concepts. "Wireless" means communication without the use of landlines. "Mobile" means that the devices are not continuously fixed to a certain place. Mobile does not certainly mean wireless. For example, PDAs (Personal Digital Assistants) are mobile but not necessarily linked through wireless networks, and TV satellite network links are wireless but not necessarily mobile.

4.2.1 Mobile Devices

There is a variety of mobile devices ranging from pagers, cell phones, PDAs to laptop computers and specific devices.

(1) Pagers

A pager is an electronic device used to contact people via a paging network. It pre-dates mobile phone technology, being most popular during the 1980s and 1990s, but similarly uses radio transmissions to communicate between a control/call center and the recipient. Pager subscriptions have been on the decline since the widespread availability of mobile phones. Pagers have the advantage of distributing text information to large numbers of recipients simultaneously by using group call features.

(2) Cell phones

Most current cell phones connect to a cellular network of base stations (cell sites), which is in turn interconnected to the public switched telephone network (PSTN) (the exception are satellite phones). In addition to the standard voice function of a telephone, a mobile phone can support many additional services such as SMS (Short Message Service) for text messaging, wireless email, packet switching for access to the Internet, and MMS (Multi-Media Message Service) for sending and receiving photos and video. Further applications include location services, etc.

Decreasing size, new data display technologies, and longer lived batteries may further enhance cell phone technology. "Small and light-weight" have long been the most important criteria when purchasing cell phones. While light weight is favorable for mobile workers, cell phones have become smaller and smaller, to some extent limiting their usability for commercial applications; the small size of the display allows only a few lines of text and only a limited display of graphics and colors, and the keyboard is designed for typing in numbers rather than text. Although word recognition software can be integrated into cell phone functionalities, entering an e-mail or Internet address can be an arduous task.

(3) Radiophone

A radiophone is a communications device that allows two or more people to talk using radio. While in recent years the cell phone has largely superseded radiophones for the average user, they are still widely used in many more specialist applications: police communications, emergency services, taxi services, and private mobile radio networks (PMR).

(4) Personal Digital Assistants

Personal digital assistants (PDAs) are handheld computers that were originally designed as personal organizers, but became much more versatile over the years. PDAs are also known as pocket computers or palmtop computers. PDAs may have a variety of applications: calculations, use as a clock and calendar, playing computer games, accessing the Internet, sending and receiving e-mails, video recording, typewriting and word processing, address book, making and writing spreadsheets, receiving radio or stereo, and location positioning through Global Positioning System (GPS). Newer PDAs also have both color screens and audio capabilities, enabling them to be used as mobile phones (smartphones), web browsers, or portable media players. Many PDAs can access the Internet, intranets, or extranets via Wi-Fi or Wireless Wide-Area Networks (WWANs).

One of the most significant PDA characteristics is the presence of a touch screen on many PDA products. Touch screen PDAs, including Windows Pocket PC devices, usually have a detachable stylus that can be used to enter or select information on the screen. Text input is usually done in one of two ways: (1) Using a virtual keyboard, where a keyboard is shown on the touch screen. Input is done by tapping the letters. (2) Using letter or word recognition, where letters or words are written on the touch screen, and then "translated" to letters in the currently activated text field.

Many PDAs have an IrDA (Infrared) port for connectivity. This allows communication between two PDAs, a PDA and any device with an IrDA port, or between a PDA and a computer with an IrDA adapter. Most modern PDAs also have Bluetooth wireless connectivity, which is used by many mobile phones, headsets and GPS devices. In order to use such PDAs for e-mail and m-commerce they must be connected to a mobile network device. The mobile phone can be used for this purpose by linking both devices with a cable or IrDA. Some newer models have built-in network capabilities.

An important function of PDAs is synchronizing data with a PC. The possibility of connecting the PDA to a personal computer is vital to be able to synchronize addresses, phone numbers or e-mails.

(5) Smart phone

A smart phone is a full-featured mobile phone with personal computer-like functionality. It integrates the functionality of a mobile phone, personal digital assistant (PDA) or other information appliance. Most smartphones are camera phones that support full featured email capabilities with the functionality of a complete personal organizer. An important feature of most smartphones is that applications for enhanced data processing and connectivity can be installed on the device, by contrast to regular phones which support specially developed applications. These applications may be developed by the manufacturer of the device, by the operator, or by any other third-party software developer. "Smart" functionality includes any additional interface including a miniature QWERTY keyboard, a touch screen, or even just secure access to company mail, such as as that provided by a RIM BlackBerry.

(6) Portable computers

Portable computers are also called notebook or laptop computers. They are capable of the same tasks as a desktop PC, although they are typically less powerful for the same price. They contain components that are similar to their desktop counterparts and perform the same functions, but are miniaturized and optimized for mobile use and efficient power consumption. Portable computers usually run on a single battery or from an external AC/DC adapter which can charge the battery while also supplying power to the computer itself. The battery has been a problem in earlier generations, but modern portable computers may work for five or six hours before recharging.

(7) Industry-specific mobile devices

In many industries the use of particular mobile devices is common. Examples are: 1) Parcel deliverers use a hand-scanner to let the receiver indicate the receipt of goods. 2) Tow truck drivers use credit card readers to charge customers. 3) Conductors can issue tickets on a train with a handheld device that calculates prices and prints tickets. 4) Ruggedized mobile devices, such as products from Symbol[1] and Intermec[2] that can stand up to tough conditions, even in harsh, dirty or extreme environments. 5) Wearable devices for firefighters or soldiers.

Mobile devices are used by mobile workers due to their portability, connectivity, and processing power. It is expected that, to perform different tasks, different mobile workers will select different mobile devices. For example, mobile knowledge workers prefer smart phones while ruggedized mobile devices are suitable for field workers such as in warehouse. In the future, the capabilities of some of the competing classes of mobile devices will continue to expand, resulting in mergers with other classes. For example, smart phones and wireless PDAs now offer very similar functionalities.

4.2.2 Wireless Networks

Wireless networks can be classified into Wireless Wide Area Networks (WWAN) - e.g. GSM and UMTS, and WAP, Wireless Local Area Networks

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[1] See: http://www.symbol.com/products/mobile_computers/mobile_computers.

[2] See: http://www.intermec.com/eprise/main/Intermec/Content/Products/Products_ListProducts?Category=CMPTR&Family=CMPTR1

(WLAN) - e.g., IEEE 802.11, and Wireless Personal Area Networks (WPAN) - e.g. Bluetooth.

(1) Wireless Wide Area Network

Wireless Wide Area Network cells cover distances of 100 meters up to 35 km. The frequency spectrum used is not normally free, which means it has to be licensed. Since first generation networks (analogue G1) were intended for voice communications only, the data rates were quite low (4.8 kbps). The Global System for Mobile (GSM) and General Packet Radio Service (GPRS) are the second generation wireless network (digital G2) which can transfer higher data rates (GSM: 9.6 - 14 kbps; GPRS: 20 - 115 kbps). But these rates are still insufficient with respect to multimedia applications. For these purposes new 3rd Generation networks are currently being deployed. In Europe these wideband systems are called UMTS (Universal Mobile Telecommunication System) and can reach data rates up to 2 Mbps.

Recently, WiMAX network capability has been emerging. WiMAX is a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL (Digital Subscriber Link). WiMAX will provide fixed, nomadic, portable, and eventually, mobile wireless broadband connectivity. In a typical cell radius deployment of three to ten kilometers, WiMAX systems can be expected to deliver capacity of up to 40 Mbps per channel for fixed and portable access applications. This is enough bandwidth to simultaneously support hundreds of businesses with T-1 speed connectivity and thousands of residences with DSL speed connectivity. It is expected that WiMAX technology will be incorporated in notebook computers and PDAs by 2007, allowing for urban areas and cities to become "metro zones" for portable outdoor broadband wireless access.

(2) Wireless Local Area Networks

Wireless Local Area Networks cover distances from 10 m to 150 m (300m outdoors). They use the unlicensed spectrum and provide much higher data transfer rates (100 Mbps) than WWAN. Since WLAN technology has emerged as an extension to computer LANs, this type of network is specialized to data transfer. Mobile stations connected by WLANs can use simple infrastructures with Access Points (APs) and WiFi instead of base stations or can connect to one another directly in ad hoc mode.

(3) Wireless Personal Area Networks

Wireless Personal Area Networks provide short range connectivity, e.g., for digital cameras or headsets. The covered area radius is about 10m but may increase up to 100m in future. The used frequency spectrum is unlicensed and data rates are about 0.5 Mbps, thus in between WWAN and WLAN. These devices connect and disconnect as needed and have therefore a so called ad hoc topology. Most WPANs are based on the Bluetooth standard. Advantages compared to WLAN are voice support and better security.

The use of different networks for mobile workers depends on patterns of mobility. For local mobility, WiFi is enough to support mobile work. For remote mobility, WWANs such as GSM and GPRS are needed.

4.2.3 Mobile Work Support

From mobile applications that are used for mobile work force support, we have identified the following typical mobile functionalities:

(1) Mobile communication

Mobile communications include the general mobile communication functions of voice communications and text messaging, and mobile notification as well.

Mobile voice communication is the earliest and the most popular application for supporting mobile work. Mobile workers use mobile voice communication to discuss, exchange information, or to interact socially with their colleagues.

Mobile text messaging is usually handed by pagers, SMS, and mobile email. Although pagers pre-date mobile phone technology, they are still used to notify people in emergency cases. Short Message Service (SMS) is available on most digital mobile phones (and other mobile devices, e.g., Pocket PCs, or occasionally even desktop computers) that permit sending short messages between mobile phones, other handheld devices, and even landline telephones. Mobile e-mail has become a popular application on various handheld devices (such as: RIM's Blackberry, Palm Pilot, and Pocket PC devices) and smart phones. Another implementation of wireless e-mail is instant messaging where senders can interact with recipients on-line in almost real-time mode. Documents can also be sent through e-mail attachments and other solutions.

Both mobile voice communication and mobile text messaging can be used for mobile notification. Mobile notification refers to time-critical information, or event triggered information that can arise in emergencies.

(2) Mobile information searching

Mobile information searching means searching for information using mobile devices through wireless connections. This is to a large extent dependent on wireless access to the relevant databases, Intranet or Internet access, and the processing power of mobile devices.

There are three levels of information searching:

1) Enterprise information searching, such as customer information searching and inventory and shipping information checking and tracking, functionalities typically available through CRM (Customer Relationship Management) and ERP (Enterprise Resource Planning) systems.

2) Industry-specific information searching, such as physician prescribing histories, up-to-date marketing and sales information, and real estate industry multiple listing service (MLS).

3) Internet information searching on Websites or through Internet search engines.

(3) Mobile transaction processing

Transactions may include one or more well structured activities in a series of actions that have clear inputs and outputs. The goal is to process routine organizational transactions in an efficient, cost effective manner (Kirs et al. 1989). The difference between mobile transaction processing and traditional transaction processing is that wireless access overcomes geographical restrictions using the portable processing power of mobile devices. Mobile transactions can be used to enhance the efficiency of business processes, reducing transaction costs and/or improving service quality. For example, a claims adjuster may meet with a customer and use a mobile device to upload pictures of damage or other case-related digitizable evidence to a central database. Once approval is obtained, the adjuster can download customer profile and coverage information from the company's database and print a check from a printer attached to the mobile device. In this scenario, the claim payment process is streamlined, allowing on-the-spot claim adjustment and payment (Varshney and Vetter 2002).

We distinguish two kinds of transaction processing: 1) off-line transaction processing, such as scanning, data entry, and signature capture, where data are captured by on-the-spot mobile devices and uploaded for batch processing; 2) online transaction processing, where the wireless connection is used for real time processing. Samples of online transactions include: order placement, payment processing, inventory management, shipment/delivery management, and policy approval (such as insurance policy approval, and automatic loan approval).

(4) Mobile job scheduling and dispatching:

Job scheduling typically involves the assignment of scarce resources to completing tasks over time to optimize some aspect of system performance, either exactly or approximately (Aytug et al., 2005). Mobile job scheduling and dispatching includes both scheduling appointments (time, location, tasks to be done etc.) and scheduling shared resources (equipment etc.). Generally, there are two types of schedule (Aytug et al., 2005). The first is a predictive schedule. This kind of schedule develops a schedule under certain assumptions as to the execution environment (most commonly, that no exceptions will occur) and releasing it to workers to guide their decisions. In mobile work, this type of schedule is referred to as batch-mode job scheduling and dispatching. In this mode, the job assignment can be loaded into mobile devices at the beginning of the work day.

The second type of schedule is reactive scheduling or re-scheduling. This is a process of modifying the predictive schedule in the face of executional exceptions and instant job assignment or re-assignment. In mobile work, this is referred to as real time mobile job schedule and dispatching. In this mode, mobile workers receive their orders during working hours. One example is taxi dispatching.

(5) Location related service

Location related service provides mobile work support through job related location information. There are two main location related services that are used to support mobile work currently: location tracking and navigation.

a) Location tracking

Location tracking provides location information about workers or equipment. The ability to identify the location of a mobile worker or a moving target dynamically creates significant value for mobile work. One popular example is tracking courier packages so customers or courier companies know where their goods are at any time. First generation package tracking technology is barcode scanning, and second generation package tracking technology is RFID (Radio Frequency Identification), which is being adopted rapidly in a number of environments. RFID is an automatic identification method, relying on storing and remotely retrieving data stored in devices called RFID tags. An RFID tag is an object that can be attached to or incorporated into a product for the purpose of identification using radio waves. Chip-based RFID tags contain silicon chips and antennas. Passive tags require no internal power source, whereas active tags require a power source. Typically passive RFID can be accessed at only very short range, usually within a very few meters, while active RFID such as those used for highway toll data collection have ranges of perhaps 50 to 100 meters.

Vehicle tracking is used for locating and dispatching vehicles. GPS (Global Positioning System) is the main technology used for vehicle tracking. GPS is a fully-functional satellite navigation system. A constellation of more than two dozen GPS satellites broadcast precise timing signals by radio to GPS receivers, allowing a GPS receiver on the vehicle to accurately determine its location within a few meters by triangulation (longitude, latitude, and altitude) in any weather, day or night, anywhere on Earth.

GPS also allows companies to locate field personnel (for example, salespeople and repair engineers) so that they are able, for example, to dispatch the nearest engineer and provide customers with accurate personnel arrival times. In addition to GPS, network-based positioning is also used to local personal. For network-based positioning, tracking and evaluation of the user location is done through a base station network, such as the cell phone network. The mobile device sends either a signal or is sensed by the network, which uses triangulation from several base stations to determine the position of the device. Whereas GPS delivers a very accurate position (accuracy up to 5m), network-based positioning delivers a very coarse position (accuracy 100m to kms). These techniques are both outdoor positioning methods. To obtain indoor positions with high accuracy, as needed for instance in warehouses, localization methods based on WLAN, Bluetooth or infrared technologies can be applied.

b) Navigation services

The simplest way to navigate is by using cell phones. The cell phone network provides location services. By positioning a cell phone, an operator can let the user know exactly where they are as well as give detailed directions on how to get to a desired destination.

The most efficient way for navigation is to use GPS to guide travelling, such as in car navigation systems. An automotive navigation system is a satellite navigation system designed for use in automobiles. Unlike other GPS systems, these use position data to locate the user on a road. Using a road database can give directions to other locations along roads that are in the same database.

(6) Mobile office

The mobile office is the mobile version of the traditional office. The functions of a mobile office include word processing, spreadsheet, presentation software, and database applications, as well as calendar, address book, and calculator. These are equivalent to the functions that PDAs and laptops have. Cell phones have relatively limited built in functionalities such as notes, calendars, address books, and task lists.

In summary, this study has discussed six typical mobile technology functions: mobile communication (voice communication, text messaging, and mobile notification), mobile information searching, mobile transaction processing (offline and online), location related services (location tracking and navigation), mobile job dispatching (batch mode and real time job dispatching), and mobile office functions. These are summarized in Table 8.

4.2.4 Dimensions to Characterize Mobile Work Support Functions

Based on the Gorry and Scott Morton framework (Gorry and Scott Morton 1971), Zmud (1983) classified information systems in terms of variations in the structural complexity of decisions, contending that there are three types of information systems: transaction processing systems, information reporting systems, and decision reporting systems. Time and location are dimensions that classify mobile applications (Balasubramanian et al., 2002; Liang and Wei 2004) as shown in the literature review.

Table 8: Typical Functionalities of Mobile Work Technology Support

	Functionalities		Examples
1	Mobile communication	Voice communication	Conversation; Discussion; Information exchange
		Text messaging	Short messages; Mobile emails.
		Notification	Time-critical messages; Event trigged information
2	Mobile information searching		Customer and market information; Mobile CRM; Mobile ERP; Industry information systems access, such as real estate industry multiple listing service (MLS); Stock information; Market information
3	Mobile transaction processing	Off-line	Scanning/Signature/Printing/Data entry
		Online	Mobile inventory management; order processing; shipment/delivery management; policy approval (Insurance policy approval, automatic loan approval)
4	Location related service	Location tracking	Tracking personal locations by GPS
		Navigation	GPS navigation systems
5	Mobile job dispatching	Batch mode	Job assignment (Task contents; expected completion time; location related information; customer related information); Job completion report;
		Real time	Real time job assignment and dispatching, job tracking and monitoring, automatic reporting
6	Mobile office		Word processing, spreadsheet, power point presentation, etc.

Based on the work of Liang and Wei (2004), Balasubramanian et al. (2002), and Zmud (1983), we can characterize mobile work support functionalities along the three dimensions: degree of structure (Table 9), degree of time criticality (Table 10) and degree of location sensitivity (Table 11).

Table 9: Mobile Work Support in Terms of Degree of Structure

Degree of structure	Examples
Well-structured	Mobile off-line transaction processing
	Mobile online transaction processing
Semi-structured	Batch mode mobile job dispatching
	Real time mobile job dispatching
Ill-structured	Mobile communication
	Mobile information searching
	Mobile office

Table 10: Mobile Work Support in Terms of Time Criticality

Degree of Time-Criticality	Examples
Not time critical	Mobile office
	Mobile offline transaction processing
Real time, always online, time critical	Mobile communication
	Real time mobile job dispatching
	Real time location tracking

Table 11: Mobile Work Support in Terms of Location Sensitivity

Degree of Location Sensitivity	Examples
Independent of location information	Mobile communication Mobile office Mobile transaction processing Mobile information searching
Dynamic location information is critical	Location tracking
	Navigation

4.3 Benefits of Mobile Work Support

Organizations that spend millions of dollars on information technology are primarily concerned about how their investments will influence organizational and individual performance (Torkzadeh and Doll 1999). The benefits of information systems can be examined at two levels: organizational level, and process level. At the organization level, there are three major types of objectives of organizational investment: strategic, informational, (Gory and Morton 1971; Turner 1985; Kirs et al., 1989; Weil 1992; Mirani and Lederer 1998) and financial. Strategic benefits include competitive advantage and customer relations. Informational benefits include information access, information quality, and information flexibility.

The benefits of information systems at the process level include productivity and management control (Gory and Morton 1971; Turner 1985; Kirs et al., 1989; Weil 1992; Mirani and Lederer 1998; Doll and Torkzadeh 1998; Torkzadeh and Doll 1999). Task productivity refers to the extent that an application improves user outputs per unit time. Information technology impacts on task productivity have been discussed in numerous studies (Braverman 1974; Curley and Pyburn 1982; Hirschhorn and Farduhar 1985; Zuboff 1988; Kraemer and Danziger 1990; Liff 1990; Weick 1990; Sulek and Marucheck 1992). Management control implies that applications help to monitor and regulate work processes and performance. Many authors suggest that one of the initial intents for using a new technology is to increase management control (Braverman 1974; Hirschhorn 1981; Shaiken 1985; Zuboff 1988; Kraemer and Danziger 1990). The above benefits of information systems are summarized in Table 12.

Table 12: Benefits of Information Systems

Level	Benefits of IS
Organizational	Strategic: competitive advantage; customer relationships
	Financial
	Informational
Process	Productivity
	Management control

Just like general information systems, mobile work technology support systems also have these benefits. Existing cases have demonstrated the benefits that users get from implementing mobile technology support. For competitive advantage, for example, Fedex introduced a nationwide cellular-based wireless data service in the late 1980s. The implementation of this mobile solution resulted in an increase in its market share and the retention of the company's competitive edge. This forced UPS to do the same or better, through its introduction of parcel barcode tracking in 1993 (Hayes and Kuchinskas 2004). For customer relationship management, Nah et al.'s (2005) study of mobile applications in a utility company shows that real-time access to up-to-date customer and utility service information helps improve the quality of services and customer communication. For informational benefits, Hayes and Kuchinskas's (2004) case study of a beverage company's mobile applications, showed how the data goes to the central computer at the warehouse, which builds the next day's delivery loads. That same information goes to the company's accounting, management, pre-sales division and delivery truck drivers. The financial benefits of such mobile applications are hard to measure. However, many cases have shown that mobile applications can help to lower operating costs, by reducing paperwork and eliminating redundant work (e.g., Nah et al. 2005). For productivity improvement, Nah et al. (2005) study of mobile applications in a utility company also showed that efficiency can be improved by minimizing delay and saving time in retrieving, updating, and communicating information. For management control, the case of J.B. Hunt Transport Inc. showed that the implementation of mobile applications helps to manage fleets more efficiently. Before implementing mobile applications, fleet managers in this company spent most of their time contacting truck drivers on the phone[3].

Benefits at the organizational level are hard to measure, especially over a short time. Both academics and practitioners recognize that the success of information technology can potentially be measured through its impact on work at the level of the individual end-user (Doll and Torkzadeh 1998; Torkzadeh and Doll 1999). In this study, we will only examine the benefit of mobile work support at the process level, where we will only focus on productivity improvement, as assessed by mobile workers through perceived usefulness of mobile technology support. This is the dependent variable in this study.

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[3] See: http://www.mobileinfo.com/Case_Study/Transportation/fleet_management.htm

4.4 Hypotheses Development

Hypotheses were developed through analyses of the characteristics of tasks and the needs for related support.

4.4.1 Support for Task Complexity

According to the information processing model (Tushman and Nadler 1978; Tushman 1979), uncertainty leads to a need for information processing. Task complexity is one of the main sources of task uncertainty (Tushman 1979). If a task is non-routine, the worker must attend to substantial information processing requirements, since complex tasks require generating and evaluating alternative approaches to performing the task. Furthermore, the more complex the task, the less it is likely that the requisite information will be available. Information processing requirements are therefore positively related to task complexity (Tushman 1978; Daft and Macintosh 1981). To meet information processing requirements, processing capacity is needed. Information processing generally includes gathering data, transforming data into information, and communication and storage of information (Galbraith 1973; Tushman and Nadler 1978; Egelhoff 1991). Keller (1994) suggested that performing nonroutine tasks matched with the amount of information processing would lead to higher performance. In the mobile context, these needs translate into mobile communication, mobile information searching, and mobile office applications. Gebauer and Shaw (2004) study showed that workers performing unstructured tasks tend to use mobile business applications to access information and for communication purposes. This leads to the following hypothesis:

H1-1: The perceived usefulness of mobile general communication is positively associated with task complexity.

H1-1a: The perceived usefulness of mobile voice communication is positively associated with task complexity.

H1-1b: The perceived usefulness of mobile text messaging is positively associated with task complexity.

H1-2: The perceived usefulness of mobile information searching is positively associated with task complexity.

Tasks with low complexity can be fulfilled by fixed programs, rules, and standard operating procedures (Van de Ven and Delbecq 1974). In the mobile context, mobile transaction processing (both offline and online) is used to process well structured activities. The Gebauer and Shaw's (2004) study found that workers performing highly structured tasks tend to use mobile business applications for data processing (which corresponds with mobile transaction processing in this study). We developed the following hypotheses:

H1-3: The perceived usefulness of mobile transaction processing is negatively associated with task complexity.

H1-3a: The perceived usefulness of mobile offline transaction processing is negatively associated with task complexity.

H1-3b: The perceived usefulness of mobile online transaction processing is negatively associated with task complexity.

Mobile job dispatching (both batch mode and real time) also has defined procedures. Nilsson and Hertzum's (2005) study showed that, since home-care workers were thoroughly familiar with a regular schedule that constituted a recurrent structure forming the backbone of their weekly schedules, they downloaded the work schedule to their PDAs (i.e., batch mode mobile job dispatching). Although real time mobile job dispatching has to deal with uncertainty, job dispatching activities themselves are well structured. We developed the following hypotheses:

H1-4: The perceived usefulness of mobile job dispatching is negatively associated with task complexity.

H1-4a: The perceived usefulness of batch-mode mobile job dispatching is negatively associated with task complexity.

H1-4b: The perceived usefulness of real time mobile job dispatching is negatively associated with task complexity.

Mobile office applications are usually used by mobile knowledge workers to complete complex tasks, such as preparing and conducting presentations, analyzing data, and writing reports. For example, preparing and making presentations at the customer's site are major activities for mobile sales force (Ingram 1990); therefore, having a dynamic, on-the-spot presentation can help seal crucial deals (Yarbrough 2001). In their study of the utilization of mobile information systems for executives, Puuronen and Savolainen (1997) found that most of executives were satisfied with the mobile work support functions of text processing and presentation graphics (84% of subjects in their study are satisfied with these functions). 80% of the executives interviewed thought that the use of text processing would grow, and. 82% thought that the use of presentation graphics would grow. This leads to the following hypothesis:

H1-5: The perceived usefulness of mobile office is positively associated with task complexity.

4.4.2 Support for Task Interdependence

Task interdependence requires coordination and can be seen as an important source of work-related uncertainty (Thompson 1967; Galbraith 1973; Van de Ven et al., 1976; Tushman 1978). Some workers work independently while others must continuously adjust to one another. High interdependence occurs when workers interact cooperatively and depend on each other for information, materials, and reciprocal inputs (Emery and Trist 1969; Campion et al., 1993). When interdependence is low, workers experience greater autonomy, stability, and certainty with respect to coordination (Van de Ven et al., 1976). A mobile worker who is fairly autonomous has little need for information from others. The more substantial the task interdependence, the greater the coordination needs (Tushman 1979). Increased levels of task interdependence require more information exchange to clarify task assignments, requirements, and progress. Productivity is diminished because of time spent in coordinating (Straus and

McGrath 1994). The amount of communication is positively related to task interdependence (Tushman 1978). Based on the above, we developed the following hypotheses:

H2-1: The perceived usefulness of mobile general communication is positively associated with task interdependence.

H2-1a: The perceived usefulness of mobile voice communication is positively associated with task interdependence.

H2-1b: The perceived usefulness of mobile text messaging is positively associated with task interdependence.

4.4.3 Support for Location Sensitivity

Location theory and other spatial economic theories consider transportation related costs as a key factor in decisions about economic activities (Mennecke and Strader 2001). Location theory articulates that, with no transport costs whatsoever, all production would be concentrated in one, or a few, optimum-sized plants located at random (Valavanis 1955). For mobile work, if transportation costs do not matter, we will not need to track the location of mobile workers and assign the nearest mobile worker to the job, so anyone anywhere could do the job. In the more likely situation that mobile tasks are location- sensitive, dynamic location-related information is critical to performing mobile tasks (Chen and Kotz 2000). The Junglas and Watson (2003) study indicated that location dependence and uniqueness (locating the position of a mobile user) is an ideal fit. Based on this argument, we developed the following hypothesis:

H3-1: The perceived usefulness of location tracking is positively associated with location sensitivity.

The task environment is generally seen as a source of work-related uncertainty (Dill 1958; Thompson 1967). In the mobile context, location is one important dimension. Uncertainty arising from location will lead to information requirements. A situation that frequently occurs is that mobile workers look for their work destinations, forcing them to resort to mobile communications (Tamminen and Oulasvirta 2004). However, interacting with other people to find a place takes time. And in most cases, it is not easy to find people who have the required information. The more efficient way would be to use GPS navigation mapping systems to provide guidance. As shown in the Brown and Chalmers (2003) study on tourism and mobile technology, one problem that tourists have is finding where things are. For example, when visiting a city, many of the attractions are distributed around the city. There is therefore a need to avoid spending too much time traveling between places. In their study, the solution for this problem was electronic guidebooks and maps augmented with GPS (Brown and Chalmers 2003). This leads to the following hypothesis:

H3-2: The perceived usefulness of navigation is positively associated with location sensitivity.

4.4.4 Support for Time Criticality

Time is money and it is a scarce resource (Whipp et al., 2002). If time criticality is low for tasks, mobile workers don't need to be contacted until they get back to their fixed office or home. When time criticality is high for tasks, mobile notification is needed to inform mobile workers anytime and anywhere. If time critical information cannot reach the workers who need the information, the value of the information will be lost (Choudhury and Sampler 1997; Sampler 1998). The Gebauer and Shaw (2004) study found that mobile applications (in the form of mobile notification) could help address emergency situations. Junglas and Watson's (2003) study found that time dependence and ubiquity is an ideal fit. This leads to the following hypothesis:

H4-1: The perceived usefulness of mobile notification is positively associated with time criticality.

This is also the case for location tracking. If it is not critical for the dispatcher to know the current location of mobile workers, they can call mobile workers or ask mobile workers to call them and tell them where they are located in a certain period time. However, if time is critical, the more efficient way is to track the current locations of mobile workers through location tracking systems. Evidence of a relationship between time criticality and location tracking is shown in Basole and Chao's (2004) study of M-DSS (Mobile Decision Support Systems). They contended that information timeliness is an important criterion to the perceived usefulness of location-based M-DSS and suggested that timeliness is positively related to the perceived usefulness of location-based M-DSS (Basole and Chao 2004). This leads to the following hypothesis:

H4-2: The perceived usefulness of location tracking is positively associated with time criticality.

Time consideration is a major reason for job scheduling and dispatching (Aytug et al., 2005). Younger (1930), in perhaps the first book dedicated to scheduling, put it this way: Well-organized and carefully executed work routing, scheduling, and dispatching are necessary to produce the required quantity, of the required quality, at the required time, and at the most reasonable cost (Younger 1930). More specifically, Reinfeld contended that production control is the task of predicting, planning and scheduling work, taking into account manpower, materials availability and other capacity restrictions, and cost. This is important in order to achieve proper quality and quantity at the time it is needed, and to follow up the schedule to see that the plan is carried out, using whatever systems have proven satisfactory for the purpose (Reinfeld 1959). Scheduling of the management, control, and allocation of people and other resources on a time-critical basis can generate significant improvements in service productivity and quality (Blumberg 1994). These arguments lead to the following hypotheses:

H4-3: The perceived usefulness of mobile job dispatching is positively associated with time criticality.

H4-3a: The perceived usefulness of batch mode mobile job dispatching is positively associated with time criticality.

H4-3b: The perceived usefulness of real time mobile job dispatching is positively associated with time criticality.

Table 13 shows a matrix of the different dimensions of task characteristics and different types of mobile work support applications. The hypotheses are also shown in Table 13. Supporting literature for the hypotheses H1 to H4 is listed in Table 14.

4.4.5 Perceived Usefulness Leads to Intention to Use

In the literature, many studies based on TAM have shown that perceived usefulness of information technology (or technology), leads to an intention to use it (Davis 1989). This result has also been supported by certain studies of mobile applications (e.g., Junglas and Watson 2003). This leads to:

H5: Intention to use mobile technology support is positively associated with the perceived usefulness of mobile technology support.

Mobile technology support relevant to H5 includes: mobile voice communication, text messaging, notification, information searching, offline transactions, online transaction processing, location tracking, navigation, batch-mode job dispatching, real time job dispatching, and mobile office functionalities.

Table 13: Fit Between Task Characteristics and Mobile Technology Functionalities

		Task Complexity	Task Interdependence	Location Sensitivity	Time Criticality
Mobile communication	Voice	H1-1a	H2-1a		
	Text messaging	H1-1b	H2-1b		
	Notification				H4-1
Mobile information searching		H1-2			
Mobile transaction processing	Offline	H1-3a			
	Online	H1-3b			
Location related service	Location tracking			H3-1	H4-2
	Navigation			H3-2	
Mobile job dispatching	Batch-mode	H1-4a			H4-3a
	Real time	H1-4b			H4-3b
Mobile office		H1-5			

Table 14: Supporting Literature for Hypotheses H1 to H4

Hypotheses	Supporting literature
H1-1a, H1-1b, H1-2	Tushman and Nadler (1978); Keller (1994); Gebauer and Shaw (2004).
H1-3a, H1-3b	Van de Ven and Delbecq (1974); Gebauer and Shaw (2004)
H1-4a, H1-4b	Van de Ven and Delbecq (1974); Nilsson and Hertzum (2005)
H1-5	Tushman and Nadler (1978); Keller (1994); Ingram (1990); Yarbrough 2001); Puuronen and Savolainen (1997)
H2-1a, H2-1b	Van de Ven et al. (1976); Tushman (1978); Tushman and Nadler (1978); Tushman (1979); Straus and McGrath (1994)
H3-1	Location theory: Mennecke and Strader (2001); Valavanis (1955). Junglas and Watson (2003); Chen and Kotz (2000)
H3-2	Tamminen and Oulasvirta (2004); Brown and Chalmers 2003)
H4-1, H4-2	Time studies: Choudhury and Sampler (1997); Sampler (1998); Whipp et al. (2002). Gebauer and Shaw (2004); Junglas and Watson (2003); Basole and Chao (2004)
H4-3a, H4-3b	Aytug et al. (2005); Blumberg (1994).

Chapter 5: Research Design

5.1 Research Method

This study used quantitative survey research to test the research model. Quantitative research is designed to ensure objectivity, generalizability and reliability (Babbie 2000). Relevant techniques cover the ways research participants are selected randomly from the study population in an unbiased manner, the standardized questionnaire they receive, and the statistical methods used to test predetermined hypotheses regarding relationships between specific variables. The researcher is considered external to the actual research, and results are expected to be replicable no matter who conducts the research. The strengths of the quantitative paradigm are that its methods produce quantifiable, reliable data that are usually generalizable to some larger population. Quantitative approaches aim to test hypotheses, and usually to identify numerical differences between groups. The greatest weakness of the quantitative approach is that it decontextualizes human behavior in a way that removes the event from its real world setting and ignores the effects of variables that have not been included in the model.

5.2 Operationalization of the Constructs

The measures for task complexity, task interdependence, perceived usefulness, and intention to use were developed by modifying instruments already developed and used by other researchers. The scales developed and validated by Withey et al. (1983) to measure task variety and analyzability were adapted to measure task complexity (Withey et al., 1983). Withey et al. (1983) evaluated six of the most important studies in which various instruments were used to assess Perrow's two task dimensions: variety and analyzability. Each dimension consisted of five questions, requiring respondents to indicate their perceptions of task on a 7-point Likert type scale ranging from (1) to a small extent to (7) to a great extent. These instruments were also used by Kim et al. (1998). In this study, the Cronbach's alpha were 0.895 for variety (5 items) and 0.896 for task analyzability (5 items). As discussed earlier, it is often difficult to tease out these two separate dimensions in practice (Van de Ven and Delbecq 1974). So some studies measure task complexity as one concept and not separately (Tushman and Nadler 1978; Goodhue and Thompson 1995). We selected five items from Withey et al.'s (1983) instruments and changed the wording to adapt to this study. Besides the five items, we added a new item: "Your work needs to handle unexpected events". All items were rated on a 1-7 Disagree-Agree scale.

Scales of task interdependence developed and validated by Pearce et al. (1992) were adapted to measure task interdependence in this study (Pearce et al., 1992). Their six-item scale of task interdependence was assessed by three researchers. The Cronbach alpha gotten by the three researchers were 0.88, 0.95, and 0.97. These scales have also been used by Sharma and Yetton (2003). We adapted Peace et al.'s (1992) six-item scales with little wording changes in this study, except that our scale was rated on a 1-7 Disagree-Agree scale instead of their 1-5 Disagree-Agree scale.

Perceived usefulness items were adapted from Davis et al's (1989) perceived usefulness scale. Their instruments of perceived usefulness are widely used (e.g., Bhattacherjee 2001). We selected three of the four items in Davis et al.'s (1989) instrument.

The items for measuring intention to use were modified from David's (1989) instrument of intention to use in a TAM study. This instrument is widely used (e.g.,Dishaw and Strong 1998).

In the literature, there is no existing measurement for the constructs of time criticality and location sensitivity. New items were developed to measure these constructs. Six items were developed to measure time criticality, and location sensitivity was measured along two aspects: location variety (3 items) and location dependence (4 items).

All instrument items were measured on a seven point Likert scale. Measurement items are listed in Tables 15 to 20. The questionnaire itself is attached as appendix B.

For the six task complexity items, except item COM2, all the other five items will be reverse coded to make that the higher scale, the higher degree of task complexity.

For task interdependence, the items of INTER1, INTER2, INTER4, INTER5 will be reverse coded to make that the higher scale, the higher degree of task interdependence.

Table 15: Measurements of Task Complexity

Identifier	Measurement items To what extent do you agree with the following statements on the degree of **task complexity?**	Scales
COM1*	Your work **is repetitive**	Scales from 1 to 7: 1-Strongly disagree; 4-Neutral; 7-Strongly agree
COM2	Your work needs to handle **unexpected events**	
COM3*	There is a **clearly known way** to do the major types of your work	
COM4*	You can rely on **established procedures**	
COM5*	Your work is **routine**	
COM6*	There is an **understandable sequence of steps** that can be followed in doing your work	

***: Reverse coding**

Table 16: Measurements of Task Interdependence

Identifier	Measurement items To what extent do you agree with the following statements on **task interdependence?**	Scales
INTER1*	Your work can be performed **fairly independently** of others	Scales from 1 to 7: 1-Strongly disagree; 4-Neutral; 7-Strongly agree
INTER2*	Your work can be planned with **little need to coordinate** with others.	
INTER3	Your work requires **frequent coordination** with others (customers, co-workers, supervisors)	
INTER4*	Your work **rarely requires obtaining information from others** to complete this task.	
INTER5*	Your work is relatively **unaffected by** the performance of others.	
INTER6	Your work depends on **receiving information from others.**	

***: Reverse coding**

Table 17: Measurements of Time Criticality

Identifier	Measurement items	Scales
TIME1	Usually, what is the average **time window (from start to finish)** for you to complete a typical task?	1. No Restriction 2. Within a week 3. Within a few days 4. Within a day 5. Within a few hours 6. Within an hour 7. Within 10 minutes
TIME2	What is the time **urgency** for you to start or finish your typical task?	1. Take it easy 2. Allow delays 3. Allow a little delay 4. At normal speed 5. Better done sooner 6. Immediate 7. In a hurry
To what extent do you agree with the following statements On the **time criticality** of your task?		
TIME3	It is very important for you to **start your task on time**	Scales from 1 to 7: 1-Strongly disagree; 4-Neutral; 7-Strongly agree
TIME4	It is very important for you to **complete your task on time**	
TIME5	It is very important for you to **start your task as soon as possible**	
TIME6	It is very important for you to **complete your task as soon as possible**	

Table 18: Measurements of Location Sensitivity

Identifier	Measurement items	Scales
Location variety:		
LOCVAR1	To what extent do you work at various locations?	Scales from 1 to 7: 1. Always the same locations 4. Some at same location, but some at different new locations 7.Always at different new locations
LOCVAR2	To what extent is your job **limited to a specific location**?	Scales from 1 to 7: 1. At one specific location 4. At several alternative locations 7. Any place
LOCVAR3	To what extent do you have the **freedom of choosing a place** to perform your work?	Scales from 1 to 7: 1. Not at all 4. Moderately 7. To a great extent
Location dependence		
LOCDEP1	To what extent is performing your work **dependent on information about your current location**?	Scales from 1 to 7: 1. Not at all 4. Moderately 7. To a great extent
LOCDEP2	To what extent is performing your work **dependent on information about other people's** (such as co-workers or customers) **locations**?	
LOCDEP3	To what extent is performing your work **dependent on information about** the **location of things or equipments** that are related to your work?	
LOCDEP4	To what extent is performing your work **dependent on information about travel or navigation guides** to the destination?	

Table 19: Measurements of Perceived Usefulness

Identifier	Measurement items For each of the following mobile work support functionalities: Mobile voice communication; text messaging; notification; information searching; off-line transaction processing; on-line transaction processing; location tracking; navigation; batch-mode job dispatching; real-time job dispatching; and mobile office:	Scales
PU1	To what extent do you perceive it would **increase the productivity** of your work?	Scales from 1 to 7: 1. Not at all 4. Moderately 7. To a great extent
PU2	To what extent do you perceive it would **improve the performance** of your work?	
PU3	To what extent do you perceive it would be **useful** for your work?	

Table 20: Measurements of Intention to Use

Identifier	Measurement items For each of the following mobile work support functionalities: Mobile voice communication; text messaging; notification; information searching; off-line transaction processing; on-line transaction processing; location tracking; navigation; batch-mode job dispatching; real-time job dispatching; and mobile office:	Scales
IU1	To what extent do you **intend to use** it?	Scales from 1 to 7: 1. Not at all 4. Moderately 7. To a great extent
IU2	To what extent do you **would like to use** it?	
IU3	To what extent do you think it **should be used**?	

5.3 Instrument Validity

Three evaluation criteria are essential to instrument development: content validity, construct validity, and reliability (Gefen 2002).

Content validity is a qualitative assessment of whether measures of a construct capture the real nature of the construct (Gefen 2002), and is usually established through the literature. Also, a pre-test is conducted to assess the content validity of the instruments.

Construct validity asks whether the measures chosen are true constructs describing the event or merely artefacts of the methodology itself (Campbell and Fiske 1959; Cronbach 1971). If constructs are valid in this sense, one can expect relatively high correlations between measures of the same construct using different methods, and low correlations between measures of constructs that are expected to differ (Campbell and Fiske 1959). Researchers should establish two main types of construct validity: convergent and discriminant, for their constructs.

Convergent validity focuses on the degree to which two or more attempts to measure the same construct through maximally different methods are in agreement (Bagozzi 1980). CFA or Squared Multiple Correlations (SMC) is used to demonstrate convergent validity. In this study, convergent validity was tested using CFA by assessing the fit of measurement model and examining the loadings and the t-value. AVE was also examined for convergent validity test in this study.

Discriminant validity is concerned with the possibility that users respond so similarly to questions on two supposedly distinct constructs that there is no empirical evidence that two different things are being measured (Goodhue 1998). Discriminant validity is usually demonstrated using Campbell and Fiske's (1959) multitrait-multimethod (MTMM), exploratory factor analysis (EFA), confirmatory factor analysis (CFA) (Nunnally 1978; Long 1983), AVE (Average Variance Extracted) Method proposed by Fornell and Larcker (1981) or cross loading method. A more rigorous and more widely accepted SEM (Structural equation modeling)-based approach to discriminant validity is to run the model unconstrained and also constraining the correlation between constructs to 1.0. If the two models do not differ significantly on a chi-square difference test, the researcher fails to conclude that the constructs differ (Bagozzi 1991). In this procedure, if there are more than two constructs, one must employ a similar analysis on each pair of constructs, constraining the constructs to be perfectly correlated and then freeing the constraints. We will use this method along with AVE method to assess the discriminant validity.

Reliability concerns the extent to which measurements are repeatable (Nunnally and Durham 1975), or have a relatively high component of true score and relatively low component of random error (Carmines and Zeller 1979). In other words, reliability tells us the degree to which a measure is clouded by random error (Goodhue 1998). The reliability of a multi-item measure is estimated by Cronbach's alpha or Composite Reliability (CR) (Fornell and Larcker 1981). Both of them will be used in this study to test the reliability.

5.4 Sampling and Data Collection

5.4.1 Respondent Selection

This research was implemented as a field study employing survey methods. The subjects of the study were real mobile workers. This type of research design does not allow us to control some variables, as in a controlled experiment (Conte et al., 1986). The use of a "real world" context, however, does assist us in attaining a higher degree of external validity (Kidder and Judd 1986). External validity has to do with possible bias in the process of generalizing conclusions from a sample to a population, to other subject populations, to other settings, and/or to other time periods. Using real mobile workers as subjects is critical to establishing external validity, as Seddon (2006) contended that the justification for making generalizations to other settings ultimately depends on the representativeness of the sample, not statistical inference.

Based on the Gartner (2002) report, we identify the following types of mobile workers as our subjects: managers, mobile sales force, mobile professionals (consultant, inspectors, etc.), transportation/delivery workers including taxi drivers, field service (maintenance and installation service) workers, and emergency service workers (such as car towing).

5.4.2 Respondent Recruitment

In order to increase the response rate, we gave a ten-dollar Tim-Hortons gift certificate to each respondent who completed the questionnaire. According to a study by Jobber et al. (2002), the inclusion of any financial incentive, regardless of the amount, raises the response rate by approximately fifteen percent.

We used two ways to recruit respondents: email and in person. Generally, we used email to reach managers, mobile sales people, and mobile professionals across Canada. It is very hard to reach mobile knowledge workers one by one in person. We contacted transportation/delivery workers, field service workers, and emergency workers in person within the city of Hamlton, Ontario, Canada (including Burlington). It is easier to meet field workers at times when they are working, away from their companies. Usually field workers do not use e-mail or access the Internet, so it is virtually impossible to reach them by e-mail.

The procedure for e-mail recruiting was as follows:

1) Search: We searched for e-mail addresses and names on the Internet from public information Web pages, and identified appropriate candidates, based on the nature of companies they worked for, and their job positions.

2) Request: Initial e-mail were sent to request voluntarily participation in the study and to complete the questionnaire. Respondents had three possible ways to complete the questionnaire: a) complete it in a Word file and send it back by e-mail; b) print it out, fill it out with pen or pencil, and return the completed questionnaire by fax; or c) Fill out the questionnaire online. In order to receive the gift certificate, the respondents needed to supply their regular mailing address by e-mail or fax.

3) Remind: If we did not receive a reply after about one week to one month, a follow-up reminder e-mail was sent.

4) Acknowledgment. After we received the completed questionnaire, we sent a thank-you e-mail and mailed the ten dollar Tim-Hortons gift certificate to the respondents.

The procedure for face to face recruiting was as follows:

1) Find mobile workers in the field: From the types of cars people drive, we could generally identify mobile workers. We approached mobile workers in public places such as parking lots when they were taking a break or were not busy.

2) Introduced the purpose of the study and the questionnaire to complete.

3) Questionnaire: The mobile workers could complete the questionnaire on the spot. When they were filling it, if they had any questions, we explained it to them. If they wanted to participate but did not have time right away, they were given a pre-paid envelope with the questionnaire enclosed, to complete and mail back.

4) Acknowledge: After mobile field workers completed the questionnaire, they were given the ten-dollar Tim Hortons gift certificate. For mobile field workers who mailed back the completed questionnaire, the ten-dollar gift certificate were sent to them.

5.5 Data Analysis Method

In this study both linear regression and SEM were used to test the research model (Dishaw and Strong 1998). Linear regression was used to test and explore the relationships between different constructs. SEM was used to assess the overall model fit and test the structural model together.

5.5.1 Multiple Regression

Regression analyses are a set of statistical techniques that allow one to assess the relationship between one dependent variable and several independent variables. Regression techniques can be applied to a data set in which independent variables are correlated with one another and with the dependent variable to varying degrees. Because regression techniques can be used when independent variables are correlated, they are helpful both in experimental research and in observational or survey research. The flexibility of regression techniques is, then, especially useful to the researcher who is interested in real-world or very complicated problems that cannot meaningfully reduced to orthogonal designs in a laboratory setting. There are three major analytical strategies in multiple regression: standard multiple regression, sequential (hierarchical) regression, and statistical (stepwise) regression. This study used the standard multiple regression method, supported by SPSS 12.0.

5.5.2 SEM

SEM (Structural equation modeling) is a multivariate statistical technique used to examine direct and indirect relationships between one or more independent latent variables and one or more dependent latent variables. Mathematically, structural equation modeling (SEM) combines CFA (Confirmatory Factor Analysis) and path analysis, and it has been referred to as a hybrid of path analysis (Kline 1991). SEM evaluates an entire hypothesized multivariate model, including the hypothesized structural linkages among variables, and between each variable and its respective measure. The general form of a SEM consists of two parts: the measurement model and the structural model. The measurement model specifies how the latent variables or the hypothetical constructs are measured in terms of the observed variables, and it describes the measurement properties, such as the validities and reliabilities, of the observed variables. The structural equation model specifies the causal relationships among the latent variables and describes the causal effects and the amount of unexplained variance (Musil et al., 1998).

SEM has some advantages over multiple regression and path analysis. In path analysis it is assumed, unrealistically, that underlying constructs and the scales used to measure them are identical (Musil et al., 1998). With SEM, the reliabilities of each of the latent variables considered in the analysis can be assessed. When predictor variables do not account for changes in outcome variable(s), it is possible to determine whether this is because of lack of correlation between the variables or because of poor reliability of the operational measures of those variables. SEM assesses the degree of imperfection in the measurement of underlying constructs, whereas regression and path analyses do not distinguish between less than perfect measurement of variables and non-random, unexplained variance. SEM allows for modeling of the unexplained variance in that it takes it into account the structural equations (Musil et al., 1998).

Another commonly acknowledged strength of SEM is the availability of measures of overall fit that can provide a summary evaluation of even complex models that involve a large number of linear equations. Most alternative procedures that might be used in place of SEM (e.g., multiple regression) to test such models would provide only separate "mini-tests" of model components that are conducted on an equation-by-equation basis. In addition, via nested chi-square tests and other means, users can comparatively evaluate the fit of alternative models that differ in complexity. In this regard, SEM supports the model comparison approach to data analysis (Tomarken and Waller 2005).

There are two kinds of SEM: component-based approach (such as Partial Least Square (PLS)) and covariance-based approach (such as Lisrel). PLS has some advantages over LISREL (Barclay et al. 1995; Higgins et al. 1992). Using PLS to test the research model does not need sound theory background. The sample size required is smaller. And there are no assumptions about the distribution of the variables. However, PLS lacks overall fit statistics (Hulland 1998). In order to assess the overall fit of the model, Lisrel was used in this study. Lisrel proceeds in two phases (Pedhazur 1997). In the first phase, which corresponds to a confirmatory factor analysis (CFA), a measurement model is tested. When there is evidence of an adequate fit of the data to the hypothesized measurement model, the causal model is tested by SEM.

The measurement model stipulates the hypothesized relationships among latent and manifest variables. In LISREL, constructs are treated as unobserved variables measured by two or more fallible indicators. Thus, a major strength of LISREL is that it enables researchers to separate latent variables from errors, and then to study causal relationships among latent variables. The process depends on the judicious selection of indicators. A faulty selection of measured variables to represent a latent variable, leads to questions about whether the theory's constructs are really embedded in the causal model. During the measurement model phase, LISREL tests three things: (1) causal relationships between measured and latent variables, (2) correlations between pairs of latent variables, and (3) correlations among the errors associated with the measured variables. The measurement model is essentially a factor analytic model that seeks to confirm a hypothesized factor structure. Thus, loadings on the factors (the latent variables) provide a method for evaluating relationships between observed and unobserved variables. The hypothesized measurement model is then tested against actual data using Lisrel. The analysis provides loadings of the observed variables on the latent variables, and the correlation between the two latent variables. The analysis also indicates whether the overall model fit is good, based on a goodness-of-fit statistic. If the hypothesized model is not a good fit, the measurement model can be re-specified and retested.

The Structural Equation Model Phase: After an adequate measurement model has been found, the second phase of Lisrel can proceed. As in path analysis, researchers specify the theoretical causal model to be tested. In this part of the analysis, Lisrel yields information about the hypothesized causal parameters - that is, the path coefficients. The coefficients indicate the expected amount of change in the latent endogenous variable that is caused by a change in the latent causal variable. The Lisrel program provides information on the significance of individual paths. The residual terms - the amount of unexplained variance for the latent endogenous variables - can also be calculated from the Lisrel analysis. The overall fit of the causal model to the research data can be tested by means of several alternative statistics.

Chapter 6: Data Analysis and Discussion

This chapter is organized as follows: First, data collection procedures and the profile of the respondents are introduced. Second, instrument validation of the constructs in this study is conducted. Third, the nature of mobile work and differences between mobile knowledge workers and field workers are examined. Fourth, the current usage, perceived usefulness of mobile functions, and intention to use them are examined. Fifth, the hypotheses are tested.

6.1 Data Collection Procedure and the Profile of Respondents

6.1.1 Data Collection Procedure

Data collection proceeded in two phases:

6.1.1.1 Pre-test. The objectives of this phase were: to test the instruments for comprehension, clarity, ambiguity, and difficulty in responding to; to test the questionnaire for length and for completion time; to revise the questionnaire as required, leading to an instrument that could be formally validated.

In November, 2005, the first draft of the questionnaire was distributed to a small sample of MBA and PhD students. 12 questionnaires were collected. Feedback included: a) the wording was not quite clear. b) Some terms could not be understood, such as the definition of mobile tasks. c) The questionnaire was long. d) Some questions were hard to answer. These comments led to an improved questionnaire.

In the 2006 winter term (Jan. 2006 – April 2006), the second draft of the questionnaire was distributed to a small sample of mobile workers by an MBA student. 13 valid questionnaires were collected. In July 2006, the online questionnaire link was distributed through the MERC (McMaster E-Business Research Center) e-mail link, which has about 300 contacts. This resulted in 8 responses. In summer 2006, 11 questionnaires were completed by friends of the researcher.

Thus, for the second draft of the questionnaire, a total of 32 valid questionnaires were obtained. Cronbach's Alpha was calculated for each construct using the data collected. Cronbach's Alpha of task related constructs are shown in table 21. All values were above 0.70, the threshold for an acceptable Cronbach's Alpha suggested by Nunnally (1978). Cronbach's Alpha of all the perceived usefulness and intention to use functions was above 0.90. These pre-test results gave us confidence in the construct reliability. The questionnaire was further revised and improved, based on feedback from the pre-test.

Table 21: Alpha of Task Related Constructs in Pre-Test

Constructs	Cronbach's Alpha
Task complexity	0.735
Task interdependence	0.720
Time criticality	0.711
Location sensitivity	0.787

6.1.1.2 Full Scale Study

The full scale study was conducted in the period November, 2006 to February, 2007. Data were collected through two methods. One involved reaching mobile workers face to face. About 550 mobile workers were contacted, resulting in 100 responses, a response rate of 18.2%. Workers contacted were employed within the cities of Hamilton and Burlington, Ontario. The other method used was to send e-mails to request responses. A total of 810 emails were sent across Canada, resulting in a total of 94 responses, for a response rate of 11.6%. 62 of these responses were returned by e-mail, 14 by fax, and 18 by online survey. A summary of the response rate data appears in Table 22. The mode of these responses is summarized in Table 23.

Table 22: Requests, Responses, and Response Rate

Request method	Face-face	E-mail	Total
Number of requests	550	810	1360
Number of responses	100	94	194
Response rate	18.2%	11.6%	14.3%

Table 23: Numbers of Responses According to Mode

Response mode	Pencil & paper	E-mail	Fax	Online	Total
Number of responses	100	62	14	18	194
Valid responses	88	61	12	18	179

Among the 194 survey responses, preliminary data inspection showed that 15 responses were not valid, and were excluded. Thus a total of 179 responses were retained for analysis.

6.1.2 Testing Differences between Print and Electronic Surveys

Both electronic and print surveys were used in this study. Some studies have found that there are no significant differences between electronic and print surveys. Carini et al. (2003) examined the responses of 58,288 college students on 8 scales involving 53 items from the National Survey of Student Engagement

(NSSE) to gauge whether individuals respond differently to surveys administered via the Web and paper. The results indicated that mode effects were generally small (Carini et al., 2003). Boyer et al. also suggested that there is no reason to believe that data collected via print or electronic means differs substantively in terms of either mean response or inter-item reliability (Boyer et al., 2002).

One-way ANOVA was used to test if differences existed among the means for the different questionnaire completion methods used in this study. We compared three questionnaire completion methods: e-mail, online, and fax. E-mail and online are modes of electronic survey, and fax is actually a print-type survey. The results are shown in Table 24, with no significant differences between the means for different questionnaire completion methods.

Table 24: Comparisons of Different Questionnaire Completion Modes

Constructs	Mode	Number	Mean	Sig. of Mean Differences
Task Complexity	Email	61	4.6754	0.324
	Fax	12	4.1167	
	Online	18	4.4889	
Task Interdependence	Email	61	4.6361	0.288
	Fax	12	4.9333	
	Online	18	5.0889	
Time Criticality	Email	61	5.0885	0.125
	Fax	12	5.6667	
	Online	18	5.4333	
Location Variety	Email	61	4.5902	0.571
	Fax	12	4.2083	
	Online	18	4.2500	
Location Dependence	Email	61	3.3525	0.667
	Fax	12	3.1250	
	Online	18	3.0139	
Location Familiarity	Email	61	4.8470	0.104
	Fax	12	4.6667	
	Online	18	5.6852	

Table 24: Comparisons of Different Questionnaire Completion Modes (Cont.)

Constructs	Mode	Number	Mean	Sig. of Mean Differences
Perceived usefulness of mobile voice	Email	61	5.7484	0.816
	Fax	12	6.0000	
	Online	18	5.6483	
Perceived usefulness of mobile text	Email	61	4.4318	0.424
	Fax	12	4.0833	
	Online	18	5.0556	
Perceived usefulness of mobile batch mode job dispatching	Email	61	2.1148	0.195
	Fax	12	2.8892	
	Online	18	2.8333	
Perceived usefulness of mobile real time job dispatching	Email	61	2.5738	0.061
	Fax	12	4.0833	
	Online	18	3.2594	
Perceived usefulness of location tracking	Email	61	2.0326	0.066
	Fax	12	3.3050	
	Online	18	2.5556	
Perceived usefulness of navigation	Email	61	3.5028	0.053
	Fax	12	4.8892	
	Online	18	3.0183	
Perceived usefulness of mobile notification	Email	61	4.0490	0.537
	Fax	12	4.8325	
	Online	18	4.0372	
Perceived usefulness of mobile information searching	Email	61	4.9507	0.797
	Fax	12	5.3333	
	Online	18	4.8706	
Perceived usefulness of mobile offline transaction processing	Email	61	2.1693	0.689
	Fax	12	2.5275	
	Online	18	1.9628	
Perceived usefulness of mobile online transaction processing	Email	61	3.5790	0.799
	Fax	12	3.1950	
	Online	18	3.2778	
Perceived usefulness of mobile office	Email	61	4.9946	0.465
	Fax	12	5.4717	
	Online	18	5.6111	
Intention to use mobile voice	Email	61	5.7541	0.846
	Fax	12	6.0278	
	Online	18	5.8704	
Intention to use mobile text	Email	61	4.2350	0.366
	Fax	12	4.0000	
	Online	18	5.0185	

Table 24: Comparisons of Different Questionnaire Completion Modes (Cont.)

Constructs	Mode	Number	Mean	Sig. of Mean Differences
Intention to use mobile batch mode job dispatching	Email	61	1.9617	0.050
	Fax	12	2.8056	
	Online	17	2.9608	
Intention to use mobile real time job dispatching	Email	61	2.3443	0.256
	Fax	12	2.8333	
	Online	18	3.1481	
Intention to use location tracking	Email	61	2.1202	0.469
	Fax	12	2.6667	
	Online	18	2.5741	
Intention to use navigation	Email	61	3.6557	0.307
	Fax	12	4.4167	
	Online	18	3.2407	
Intention to use mobile notification	Email	61	4.0383	0.913
	Fax	12	4.3056	
	Online	18	4.1667	
Intention to use mobile information searching	Email	61	4.7978	0.598
	Fax	12	5.4167	
	Online	18	4.7222	
Intention to use mobile offline transaction processing	Email	61	2.3497	0.451
	Fax	12	2.6944	
	Online	18	1.8889	
Intention to use mobile online transaction processing	Email	61	3.4918	0.490
	Fax	12	3.1667	
	Online	18	2.8333	
Intention to use mobile office	Email	61	4.8415	0.264
	Fax	12	5.5556	
	Online	18	5.6667	

6.1.3 Dealing with Non-response Bias

Non-response Bias was evaluated by comparing early and late respondents (Armstrong & Overton, 1977; Kim et al. 2005; He et al. 2007). The results of t-test shown in Table 25 indicated that non-response bias should be no problem in this study.

Table 25: t-test for Comparing Early and Late Respondents

Construct	t	df	Sig. (2-tailed)
Task complexity	-1.37	177	0.17
Task interdependence	-0.93	177	0.35
Time criticality	-0.51	177	0.61
Location dependence	0.71	177	0.48
Location variety	-0.36	177	0.72
Perceived Usefulness of Voice communication	-0.65	177	0.52
Perceived Usefulness of Text messaging	-1.70	177	0.09
Perceived Usefulness of Batch mode job dispatching	0.77	177	0.44
Perceived Usefulness of Real time job dispatching	0.36	177	0.72
Perceived Usefulness of Location tracking	0.28	177	0.78
Perceived Usefulness of Navigation	1.82	177	0.07
Perceived Usefulness of Notification	-1.80	177	0.07
Perceived Usefulness of Information Searching	-2.90	177	0.00
Perceived Usefulness of Offline transaction processing	0.36	177	0.72
Perceived Usefulness of Online transaction processing	-0.01	177	0.99
Perceived Usefulness of Mobile office	-1.95	177	0.05

6.1.4 Respondent Profiles

The profile of respondents is shown in Table 26, Figure 11, and Figure 12. There were 84 field workers: 29 from the transportation/delivery industry, 44 field service workers, and 11 emergency service employees. There were 95 mobile knowledge workers, including 43 in sales, 31 managers, and 21 mobile professionals. The face to face request method was used with all 84 field worker respondents and for 4 mobile knowledge worker respondents. The e-mail request method was used with the other 91 mobile knowledge worker respondents. In Table 25, mobile work time refers to the percentage of their time that workers spent outside of their fixed offices.

The mobile work time profile for the respondents indicates that, on average, all the subjects met the definition of mobile workers. The profile shows that the sample was roughly represented the population of mobile workers (c.f. Table 27).

Table 26: Profile of Respondents

	Job Categories	Responses	Percentage of total (%)	Mobile Work Time (%)
Field workers (N=84)	Transportation/ Delivery workers	29	16.2%	70%-90%
	Field service workers	44	24.6%	67%-87%
	Emergency service workers	11	6.1%	71%-91%
Knowledge workers (N=95)	Sales force	43	24.0%	53%-73%
	Managers	31	17.3%	33%-53%
	Mobile professionals	21	11.7%	50%-70%
	Total	179	100.0%	

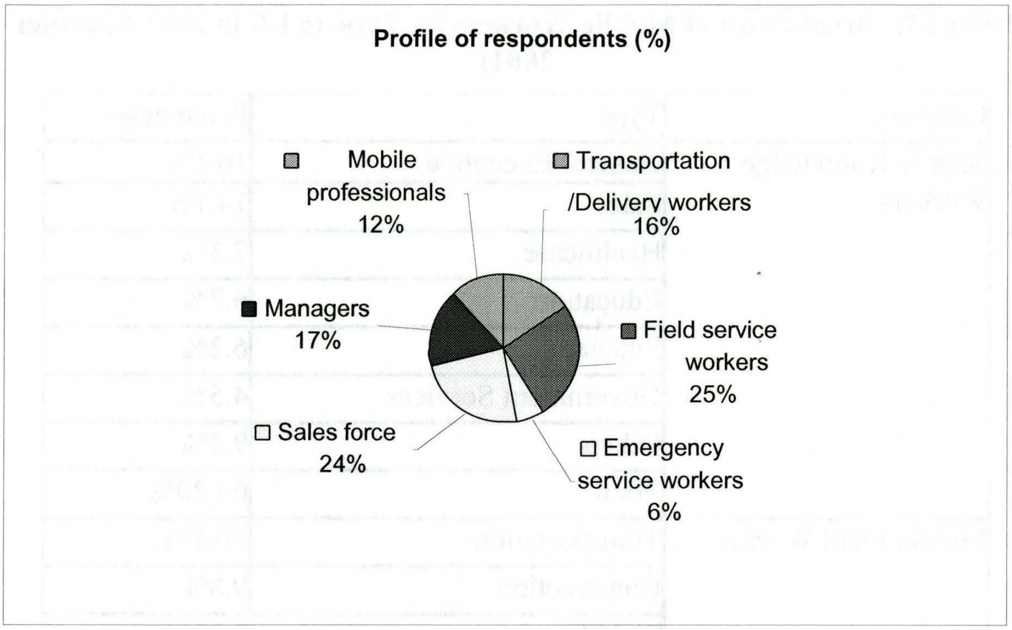


Figure 11: Profile of Respondents

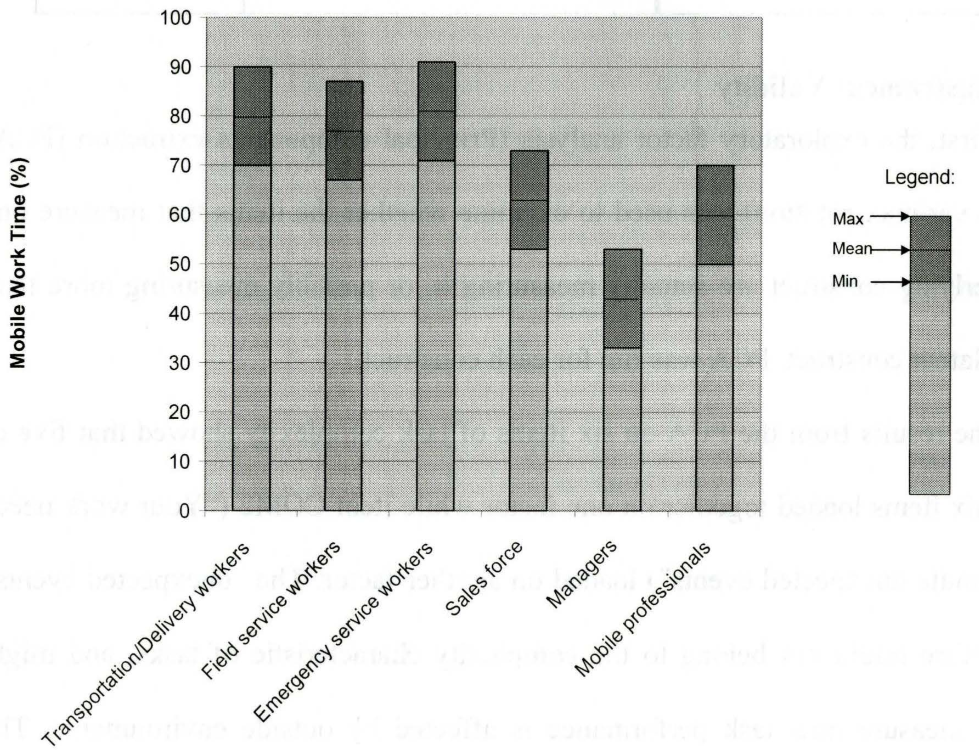


Figure 12: Mobile Work Time

Table 27: Breakdown of Mobile Workers by Type in US in 2001 (Gartner 2001)

Category	Type	Percentage
Mobile Knowledge Workers	General Executive	16.1%
	Sales	14.1%
	Healthcare	7.3%
	Education	6.7%
	Finance	6.2%
	Government Services	4.5%
	Others	9.3%
	Total	64.20%
Mobile Field Workers	Transportation	10.6%
	Construction	9.8%
	Field Service	7.8%
	Others	7.4%
	Total	35.60%

6.2 Instrument Validity

First, the exploratory factor analysis (Principal components extraction (PCA) with varimax rotation) was used to examine whether the items that measure one underlying construct are actually measuring it, or possibly measuring more than one latent construct. PCA was run for each construct.

The results from the PCA on six items of task complexity showed that five of the six items loaded together on one factor while item COM2 ("Your work needs to handle unexpected events") loaded on another factor. The "unexpected events" therefore might not belong to the complexity characteristic of tasks, and might only measure how task performance is affected by outside environments. The frequency of "unexpected events" is not related to the degree of task routinization, so this item was removed, leaving the remaining five items to measure the task complexity construct.

The results of PCA on the six items of task interdependence also showed that five of the six items loaded on one factor while item INTER6 ("Your work depends on receiving information from others") loaded on another factor. This question might not have been specific enough so we removed it, leaving the remaining five items to measure the construct of task complexity.

The results of PCA on the six items of time criticality showed that all the six items loaded on one factor.

The results of PCA on the ten items of location sensitivity showed that the seven items loaded on two factors. The two factors were actually the two aspects of location sensitivity that we proposed. So the two constructs of location variety and location dependence were used instead of just one construct of location sensitivity. The measurement item LOCVAR3 "To what extent do you have the freedom of choosing a place to perform your work?" was supposed to measure location variety, but its loading on location variety was very low, at -0.059, so it was removed. "The freedom of choosing a place to perform work" was not related to location variety. Even when mobile workers have freedom of choice, this does not appear to mean their work locations vary, especially if their work is to be done at one or two specific locations.

The results of PCA on the three items of perceived usefulness or intention to use showed that the respective three items actually measured the underlying construct.

Convergent Validity

The convergent validity was assessed by assessing the fit of the measurement model in CFA and by examining the loadings and t-values for each measurement item. AVE was also examined for the convergent validity test.

The sample size obtained in the survey is sufficient to analyze the hypothesized model using Lisrel. According to Anderson and Gerbing (1988), a sample size of 150 is needed to obtain parameter estimates that have standard errors small enough to be of practical use in Lisrel. The sample size in this study is 179, which is over the minimum requirement for Lisrel.

In Lisrel, a non-significant $\chi 2$ means a good fit. But there are problems with relying solely on $\chi 2$ as a fit statistic. The hypothesis tested by $\chi 2$ is likely to be implausible, because it may be unrealistic to expect a model to have a perfect population fit. Lisrel is sensitive to the size of the correlations: bigger correlations generally lead to higher values of $\chi 2$. It is also affected by sample size. Specifically, if the sample size is large, the value of $\chi 2$ may lead to model rejection even when differences between observed and predicted covariances are small (Marcoulides 1998; Musil et al., 1998). Thus, other fit indices were used to assess the fit of the model: the ratio of chi square to degrees of freedom (d.f.), RMSEA (Root Mean Squared Error of Approximation), CFI (Comparative Fit

Index), and NNFI (Non-normed Fit Index). The cutoff value for the ratio of chi square to degrees of freedom is 3:1 as suggested by Gefen et al. (2003) and 5:1 as suggested by Marsh and Hovecar (1985). The cutoff value of RMSEA is 0.10 as suggested by Browne and Cudeck (1993) and 0.08 as suggested by Jarvenpaa et al. (2000). The commonly used threshold of CFI is 0.90 (Gefen et al. 2000; Gefen et al., 2003; Hair et al., 1998). For NNFI (a.k.a. TLI, Tucker-Lewis Index), between 0.85 and 0.89 means a mediocre fit (model could be improved substantially); between 0.90 and 0.95 means an acceptable fit, between 0.95 and 0.99 means a good fit, and 1.00 means an exact fit (Bentler and Bonett, 1980).

The results from the measurement models are summarized in Table 28, showing that the measurement model is acceptable.

Table 28: Fit Indices for the Measurement Models

	X2	Df	χ2/df	RMSEA	CFI	NNFI
Threshold			<=0.03	<=0.10	>=0.90	>=0.90
Six task related constructs	608.41	265	2.30	0.082	0.92	0.91
Eleven constructs of the perceived usefulness of mobile functions.	959.55	440	2.18	0.082	0.86	0.85

The loadings, R^2, and t-value are shown in Tables 29 to 33. Tables 29 to 33 also show the mean and standard deviation of the measurement items. The results for perceived usefulness and intention to use constructs are not listed, as the loading for all these constructs is above 0.80 and all of them are significant.

The rule-of-thumb terms loadings as "weak" if less than 0.4, "strong" if more than 0.6, and otherwise as "moderate" (De Vaus 1991; Garson 2001; Hair et al. 1995).

From Table 31, we see that the loading of item TIME1 "Usually, what is the average time window (from start to finish) for you to complete a typical task?" is as low as 0.26, below the threshold of 0.40. So we removed this item from the measurement of time criticality. This question of "time window" appeared to be difficult for subjects to understand and answer. This was noted by comments from subjects when they were completing the questionnaire.

The AVE for each construct is listed in Table 39 to Table 41. The threshold of AVE is at least 0.5 (Fornell and Larcker 1981). All constructs' AVE are greater than 0.5, except the construct of task interdependence.

Table 29: Means, Standard Deviations, and Loadings for Task Complexity

Item	Mean	SD	Loading	R^2	t-value
COM1	4.46	2.04	0.72	0.51	
COM 2*	2.10	1.42	0.13	0.02	1.67
COM 3	3.17	1.76	0.67	0.45	8.35
COM 4	3.26	1.82	0.81	0.66	9.95
COM 5	4.46	1.98	0.71	0.50	8.78
COM 6	3.30	1.82	0.82	0.68	10.08

* Item removed due to low loading

Table 30: Means, Standard Deviations, and Loadings for Task Interdependence

Item	Mean	SD	Loading	R^2	t-value
INTER1	3.31	2.11	0.67	0.44	
INTER 2	4.34	2.05	0.65	0.43	6.58
INTER 3	5.28	1.83	0.44	0.20	4.86
INTER 4	4.77	1.99	0.46	0.22	5.05
INTER 5	5.22	1.68	0.71	0.50	6.85
INTER 6*	5.41	1.72	0.19	0.04	2.24

* Item removed due to low loading

Table 31: Means, Standard Deviations, and Loadings for Time Criticality

Item	Mean	SD	Loading	R^2	t-value
TIME1*	3.77	1.98	0.26	0.07	
TIME 2	4.74	1.20	0.40	0.16	6.42
TIME 3	5.61	1.67	0.64	0.41	8.72
TIME 4	5.98	1.46	0.56	0.31	8.62
TIME 5	5.21	1.68	0.85	0.72	3.21
TIME 6	5.53	1.55	0.82	0.68	4.74

* Item removed due to low loading

Table 32: Means, Standard Deviations, and Loadings for Location Variety

Item	Mean	SD	Loading	R^2	t-value
LOCVAR1	4.98	1.87	0.90	0.81	
LOCVAR 2	5.10	1.93	0.59	0.35	4.86
LOCVAR 3*	3.63	2.26	-0.23	0.05	-2.63

* Item removed due to low loading

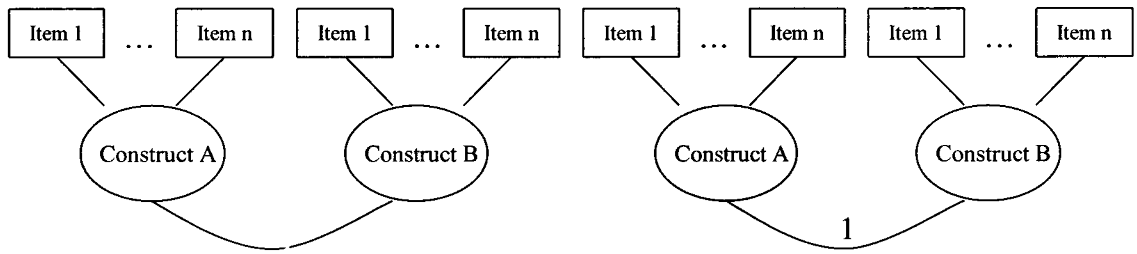
Table 33: Means, Standard Deviations, and Loadings for Location Dependency

Item	Mean	SD	Loading	R^2	t-value
LOCDEP1	3.75	2.35	0.70	0.49	
LOCDEP2	3.73	2.30	0.58	0.33	6.50
LOCDEP3	4.40	2.18	0.70	0.49	7.58
LOCDEP4	4.07	2.31	0.72	0.52	7.75

Discriminant Validity

First, discriminant validity was assessed using a series of chi-square difference tests (Bagozzi and Phillips 1982), where the $\chi 2$ statistic of the unconstrained CFA model (with all constructs freely correlated) is compared with that of a constrained model (with correlation between two constructs set equal to 1) (as shown in Figure 13). A significant $\chi 2$ difference between the two models indicates discriminant validity between the constrained pair of constructs).

Discriminant validity was tested for each pair of the six task related constructs: task complexity, task interdependence, time criticality, location variety, location dependence, and location familiarity. All pairs of the six constructs showed a significant difference, demonstrating that they are six distinct constructs. Table 34 shows some of the results.



Model 0: unconstrained Model 1: Constrained

Figure 13: Discriminant Validity Test

For the eleven perceived usefulness related constructs, we conducted discriminant analysis on all pairs, but in Table 35 we only list the results for some pairs that appear to be similar. The results of this analysis confirmed that the eleven perceived usefulness related constructs are distinct constructs.

Table 36 shows the results of the discriminant validity tests on each pair of constructs from perceived usefulness and intention to use for the eleven typical mobile functions. The results confirm that perceived usefulness and intention to use are distinct constructs.

In Table 34, Table 35, and Table 36, a pair refers to two constructs that we will test to see whether these two constructs are distinct constructs or actually one construct. Model 0 refers to the model in which the correlation between these two constructs is unconstrained, while model 1 refers to the model in which the correlation between these two constructs is constrained to 1 (as shown in Figure 13).

Discriminant validity test was also conducted by AVE method. Table 37 and Table 38 list the correlation matrix, with correlations among constructs and the square root of AVE on the diagonal. In all cases, the AVE for each construct is larger than the correlation of that construct with all other constructs in the model.

Reliability Test

AVE, CR, and Cronbach's Alpha was calculated for each construct. The results are shown in Table 39, 40, and 41. CR and Cronbach alpha of a construct should be greater than 0.7 for items to be used together as a construct (Nunnally 1978). These results all exceeded the 0.7 threshold except the construct of task interdependence

Table 34: Discriminant Validity for the Six Task Related Constructs

Pair	Model	df	$\chi 2$	Significant difference?
Location Variety – Location Dependence	0	8	12.49	$\Delta \chi 2$ (df=1) = 53.6 (p<0.001)
	1	9	66.09	
Time Criticality – Location Variety	0	13	57.26	$\Delta \chi 2$ (df=1) = 61.83 (p<0.001)
	1	14	119.09	
Time Criticality – Location Dependence	0	26	68.86	$\Delta \chi 2$ (df=1) = 139.98 (p<0.001)
	1	27	208.84	
Task Complexity – Time Criticality	0	34	128.99	$\Delta \chi 2$ (df=1) = 256.56 (p<0.001)
	1	35	385.55	
Task Complexity – Task Interdependence	0	34	113.17	$\Delta \chi 2$ (df=1) = 129.93 (p<0.001)
	1	35	243.10	

Table 35: Discriminant Validity for the Eleven Perceived Usefulness Related Constructs

Pair	Model	Df	χ2	Significant difference?
Mobile batch mode job dispatching – Mobile real time job dispatching	0	8	34.13	Δ χ2 (df=1) = 50.11 (p<0.001)
	1	9	84.24	
Mobile notification – Mobile real time job dispatching	0	8	428.49	Δ χ2 (df=1) = 250.65 (p<0.001)
	1	9	679.14	
Location tracking – Navigation	0	8	510.57	Δ χ2 (df=1) = 280.13 (p<0.001)
	1	9	790.70	
Offline transaction processing – online transaction processing	0	8	30.29	Δ χ2 (df=1) = 722.85 (p<0.001)
	1	9	753.14	
Mobile voice communication – Mobile text messaging	0	8	39.78	Δ χ2 (df=1) = 508.83 (p<0.001)
	1	9	548.61	
Mobile voice communication – Mobile real time job dispatching	0	8	41.89	Δ χ2 (df=1) = 525.94 (p<0.001)
	1	9	567.83	
Mobile voice communication – Location tracking	0	8	13.03	Δ χ2 (df=1) = 532.21 (p<0.001)
	1	9	545.24	
Mobile voice communication – Mobile notification	0	8	39.29	Δ χ2 (df=1) = 332.76 (p<0.001)
	1	9	372.05	
Mobile voice communication – Mobile information searching	0	8	13.33	Δ χ2 (df=1) = 537.24 (p<0.001)
	1	9	550.57	
Mobile text messaging – Mobile batch mode job dispatching	0	8	18.22	Δ χ2 (df=1) = 747.12 (p<0.001)
	1	9	765.34	
Mobile text messaging – Mobile real time job dispatching	0	8	11.29	Δ χ2 (df=1) = 745.53 (p<0.001)
	1	9	756.82	
Mobile text messaging – Mobile notification	0	8	29.14	Δ χ2 (df=1) = 710.26 (p<0.001)
	1	9	739.40	

Table 36: Discriminant Validity on Each Pair of Perceived Usefulness and Intention to Use Constructs

Pair: Perceived usefulness vs. Intention to use	Model	df	χ2	Significant difference?
Mobile voice	0	8	56.43	Δ χ2 (df=1) = 127.55
	1	9	183.98	(p<0.001)
Mobile text	0	8	34.15	Δ χ2 (df=1) = 373.48
	1	9	407.63	(p<0.001)
Mobile batch mode job dispatching	0	8	47.43	Δ χ2 (df=1) = 240.3
	1	9	287.73	(p<0.001)
Mobile real time job dispatching	0	8	30.70	Δ χ2 (df=1) = 276.08
	1	9	306.78	(p<0.001)
Location tracking	0	8	98.05	Δ χ2 (df=1) = 291.66
	1	9	389.71	(p<0.001)
Navigation	0	8	48.89	Δ χ2 (df=1) = 312.52
	1	9	361.41	(p<0.001)
Mobile notification	0	8	93.13	Δ χ2 (df=1) = 241.68
	1	9	334.81	(p<0.001)
Mobile information searching	0	8	16.32	Δ χ2 (df=1) = 245.31
	1	9	261.63	(p<0.001)
Mobile offline transaction processing	0	8	16.91	Δ χ2 (df=1) = 320.43
	1	9	337.34	(p<0.001)
Mobile online transaction processing	0	8	19.38	Δ χ2 (df=1) = 325.15
	1	9	344.53	(p<0.001)
Mobile office	0	8	70.40	Δ χ2 (df=1) = 207.05
	1	9	277.45	(p<0.001)

Table 37: Means, Standard Deviations, and Correlations of Task Constructs

N=179	Mean	SD	1	2	3	4	5
1. Task complexity	3.73	1.51	0.81				
2. Task interdependence	4.58	1.33	0.28 (***)	0.57			
3. Location variety	5.04	1.67	-0.34 (***)	-0.05	0.75		
4. Location dependence	3.99	1.76	-0.36 (***)	0.05	0.30 (***)	0.88	
5. Time criticality	5.41	1.14	-0.14	0.09	0.10	0.28 (***)	0.77

*: p< 0.05; **: p< 0.01; ***: p<0.001

†: Diagonal elements are the square root of AVE.

Table 38: Means, Standard Deviations, and Pearson Correlations of Perceived Usefulness of Mobile Support Functions

Perceived Usefulness of Mobile Functions	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1.Mobile Voice Communication	5.65	1.57	0.95										
2.Mobile Text Messaging	4.09	2.24	0.299 (***)	0.80									
3.Mobile Notification	4.53	2.19	0.431 (***)	0.263 (***)	0.97								
4.Mobile Information Searching	3.95	2.21	0.107	0.244 (**)	0.097	0.98							
5.Mobile Offline Transaction Processing	2.77	2.11	0.144	0.060	0.292 (***)	-0.026	0.99						
6.Mobile Online Transaction Processing	3.24	2.24	0.200 (**)	0.257 (**)	0.279 (***)	.250 (**)	0.475 (***)	0.98					
7.Location Tracking	3.28	2.29	0.157 (*)	0.112	0.383 (***)	-0.181 (*)	0.331 (***)	0.107	0.97				
8.Navigation	4.23	2.27	0.288 (***)	0.164 (*)	0.456 (***)	-0.012	0.244 (**)	0.219 (**)	0.516 ***)	0.98			
9.Mobile Batch Mode Job Dispatching	3.54	2.38	0.187 (*)	0.125	0.470 (***)	-0.107	0.338 (***)	0.175 (*)	0.497 (***)	0.410 (***)	0.98		
10.Mobile Real time Job Dispatching	4.02	2.39	0.194 (**)	0.133	0.456 (***)	-0.128	0.344 (***)	0.130	0.666 (***)	0.433 (***)	0.637 (***)	0.97	
11.Mobile Office	3.93	2.40	0.134	0.174 (*)	0.085	0.581 (***)	-0.003	0.291 (***)	-0.155 (*)	-0.013	-0.197 (**)	-0.169 (*)	0.99

N=179

*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$ †: Diagonal elements are the square root of AVE.

Table 39: AVE, CR, and Cronbach's Alpha for Task Related Constructs

N=179	Number of Items	AVE	CR	Cronbach's Alpha
Task complexity	5 (Excluding item 2)	0.65	0.90	0.86
Task interdependence	5 (Excluding item 6)	0.33	0.65	0.72
Time criticality	5 (Excluding item 1)	0.56	0.86	0.80
Location variety	2 (Excluding item 3)	0.77	0.87	0.70
Location dependence	4	0.59	0.85	0.77

Table 40: AVE, CR, and Cronbach's Alpha for Perceived Usefulness Constructs

N=179	Number of Items	AVE	CR	Cronbach's Alpha
Mobile voice	3	0.90	0.96	0.94
Mobile text	3	0.95	0.98	0.97
Mobile batch mode job dispatching	3	0.97	0.99	0.98
Mobile real time job dispatching	3	0.94	0.98	0.98
Location tracking	3	0.95	0.98	0.98
Navigation	3	0.96	0.99	0.98
Mobile notification	3	0.95	0.98	0.97
Mobile information searching	3	0.96	0.99	0.98
Mobile offline transaction processing	3	0.97	0.99	0.99
Mobile online transaction processing	3	0.96	0.99	0.98
Mobile office	3	0.98	0.99	0.99

Table 41: AVE, CR, and Cronbach's Alpha for Intention to Use Constructs

N=179	Number of Items	AVE	CR	Cronbach's Alpha
Mobile voice	3	0.91	0.97	0.95
Mobile text	3	0.95	0.98	0.97
Mobile batch mode job dispatching	3	0.94	0.98	0.97
Mobile real time job dispatching	3	0.96	0.99	0.97
Location tracking	3	0.96	0.99	0.97
Navigation	3	0.91	0.97	0.95
Mobile notification	3	0.94	0.98	0.97
Mobile information searching	3	0.92	0.97	0.96
Mobile offline transaction processing	3	0.94	0.98	0.97
Mobile online transaction processing	3	0.95	0.98	0.97
Mobile office	3	0.97	0.99	0.99

Conclusions on measurement validity

Based on the above analyses, the measurement items in this study have established reliability, and both convergent and discriminant validity except that there are problems for the construct of task interdependence (AVE is less than 0.5 and CR is less than 0.7).

6.3 Analysis on the Nature of Mobile Work

In this section, the nature of mobile work is analyzed by examining the relations between different dimensions of mobile tasks. Then differences in the nature of mobile work between mobile knowledge workers and field workers are compared.

The means, standard deviations, and Pearson correlations between task variables are shown below in Table 37. From these data, we have the following findings:

(1) Task complexity is negatively correlated with two aspects of location sensitivity (location variety and location dependence). Location variety implies resource limitations. Mobile workers usually carry or borrow the resources (Brown and O'Hara 2003). Limited resources tend to restrict the complexity of tasks that can be performed. Also, in the mobile work context, the distraction that mobile workers encounter affects their performance of complex tasks. On the other hand, when mobile workers encounter complex tasks, they usually do not complete them on the site, but take them back to the office to finish them.

(2) Task interdependence is not correlated with any aspects of location sensitivity and time criticality. This shows that task interdependence is not affected by the context in which the task is performed, such as location and time. People tend to believe that one of the greatest values of mobile technology is being connected. This is not because the degree of task interdependence of mobile work is higher than stationary work. It is because mobility may make workers lack the connections that stationary workers have in their offices.

(3) Task complexity is positively correlated with task interdependence. For complex tasks, people need to interact with others to help complete the tasks. On the other hand, a higher degree of dependence on task performance increases the complexity of performing the task.

The comparison of task characteristics between mobile knowledge workers and field workers is shown in Table 42 and Figure 14 below. Table 42 also shows t-tests for differences from the neutral value of 4.0 and mean differences between mobile knowledge workers and field workers. From these data, we have the following findings:

(1) The degree of task complexity for mobile knowledge workers is higher than that for field workers. The mean task complexity for field workers is as low as 2.80, while it is 4.55 for mobile knowledge workers (greater than the neutral value 4). Field workers usually do repetitive tasks in their work. They also usually follow a procedure when performing their work. But mobile knowledge workers normally do not do repetitive work, and they often do not follow standard procedures.

(2) The degree of time criticality for field workers is higher than that for mobile knowledge workers. Transportation and delivery workers need to delivery goods or provide transportation to people in time. Maintenance workers need to fix the problems in a certain time. Vehicle service personnel are required to arrive at the scene as soon as possible. Field workers usually are required to complete their work within at most several hours. But mobile knowledge workers usually do not need to rush or to follow a restricted time schedule. Their time is more flexible.

(3) The degree of location variety and location dependence for field workers is higher than for mobile knowledge workers. Field workers usually work outside at

different places. Most of them do not even have a fixed office. Transportation and delivery workers have to go to a specific location to pick up and drop off goods or people at a specific place. Maintenance workers have to go to specific places to fix things. Vehicle service personnel have to go to specific places to serve people. That is, their work is heavily dependent on location. Mobile knowledge workers usually still have fixed offices, although they may spend a certain of time working outside. Their mobile work is not as heavily dependent on place as is the mobile work of field workers.

(4) The degree of task interdependence for mobile knowledge workers is a little higher than that for field workers. This is because, as we discussed earlier, the degree of task complexity for mobile knowledge workers is higher than field workers, and task interdependence has a positively relationship with task complexity.

6.4 Analysis on the Usage of Technology Support

6.4.1 Current Usage of Mobile Devices and Networks

The current usage of mobile devices by mobile workers is summarized below in Table 43 and graphed in Figure 15. The current usage of networks is summarized in Table 44 and graphed in Figure 16. In Table 43 and Table 44, "frequency" refers to how many subjects answered that they used a specific mobile device or network. Percentage is the frequency divided by number of

Table 42: Comparison of Task Characteristics Between MFW and MKW[†]

N=179	MFW (N=84) Mean (t-test: difference from neutral value of 4)	MKW (N=95) Mean (t-test: difference from neutral value of 4)	Mean Difference	t-test: Mean Difference
Task complexity	2.80 (0.000)	4.55 (0.000)	-1.75	0.000
Task interdependence	4.34 (0.038)	4.80 (0.000)	-0.46	0.020
Location variety	5.65 (0.000)	4.50 (0.002)	1.15	0.000
Location dependence	4.85 (0.000)	3.22 (0.000)	1.63	0.000
Time criticality	5.51 (0.000)	4.82 (0.000)	0.69	0.000

†: MFW – Mobile Field Workers; MKW – Mobile Knowledge Workers

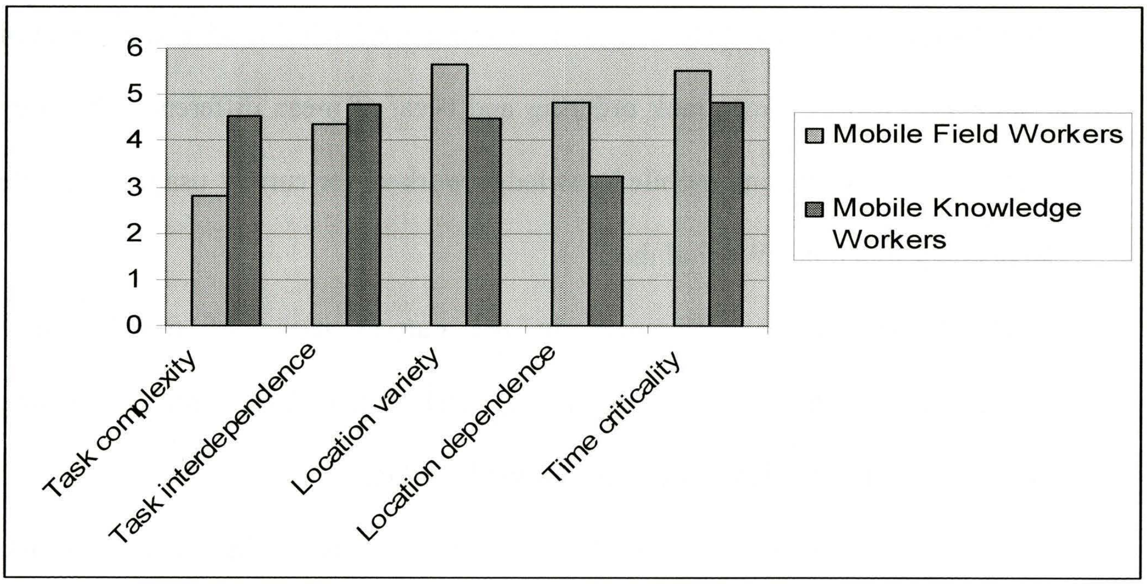


Figure 14: Comparisons of Task Characteristics between Mobile Field Workers and Mobile Knowledge Workers

respondents. Table 43 and Table 44 also show the rank order for mobile devices and networks. Mobile knowledge workers use more smart phones, laptops, and pocket PCs than field workers. Field workers use more pagers and two-way radios than mobile knowledge workers. For cell phone usage, mobile knowledge workers and field workers are almost the same. For PDAs, mobile knowledge workers usage is marginally higher than field workers. Mobile knowledge workers use more WiFi and fixed line networks, but field workers use more paging and two-way radio networks.

6.4.2 Current Usage of Mobile Functions

Comparisons of the current usage of mobile functions between mobile knowledge workers and field worker are summarized in Table 45 and graphed in Figure 17. It also shows rank ordering and t-test of mean differences between mobile field workers and mobile knowledge workers for current usage of mobile technology functions. We find that:

(1) There are no differences in the current usage of mobile voice communication, mobile text messaging, and online transaction processing between mobile knowledge workers and field workers.

(2) Field workers use more batch mode job dispatching, real time job dispatching, location tracking, navigation, and mobile notification than mobile knowledge workers.

(3) Mobile knowledge workers use more mobile information searching and mobile office functions than do field workers.

6.4.3 The Perceived Usefulness of Mobile Functions

Correlations between the perceived usefulness of the eleven typical mobile functions are shown in Table 38. This table demonstrates that:

(1) The perceived usefulness of location tracking and real time job dispatching are strongly correlated (0.666). For real time mobile job dispatching, it is useful to track location in order to optimize real time job assignments. To achieve this objective, usually the nearest mobile worker is assigned to perform the task. The dispatcher needs to know the current location of mobile workers to determine who the nearest mobile worker is. So real time job dispatching is usually combined with location tracking. This is consistent with the Bergqvist et al. (1999) study, indicating that the awareness of the position of potential participants is critical for establishing mobile meetings. Establishing mobile meetings is somewhat similar to real time mobile job dispatching.

(2) The perceived usefulness of batch mode job dispatching and real time job dispatching are positively correlated (0.637). Mobile workers are most often supported by both batch mode and real time job dispatching. They get an initial job list from batch mode job dispatching systems. But they may get a real time job assignment when unexpected things or emergencies occur.

(3) The perceived usefulness of mobile office functions and mobile information searching are positively correlated (0.581). Both of the two function are mostly used by mobile knowledge workers (as we will see below) to deal with complex tasks.

(4) The perceived usefulness of location tracking and navigation are positively correlated (0.516). Both of these functions are location based services.

Table 43: Usage of Mobile Devices

Mobile Devices	MFW† (N=84)			MKW† (N=95)		
	Frequency	Percentage	Rank order	Frequency	Percentage	Rank order
Pager	19	22.60%	4	5	5.30%	6
Cell Phone	66	78.60%	1	76	80.00%	2
Smart Phone	8	9.50%	6	38	40.00%	3
PDA	12	14.30%	5	19	20.00%	4
Pocket PC	1	1.20%	8	7	7.40%	5
Laptop	31	36.90%	3	79	83.20%	1
Special Devices	2	2.40%	7	0	0.00%	8
Two-way Radio	52	61.90%	2	3	3.20%	7

†: MFW – Mobile Field Workers; MKW – Mobile Knowledge Workers

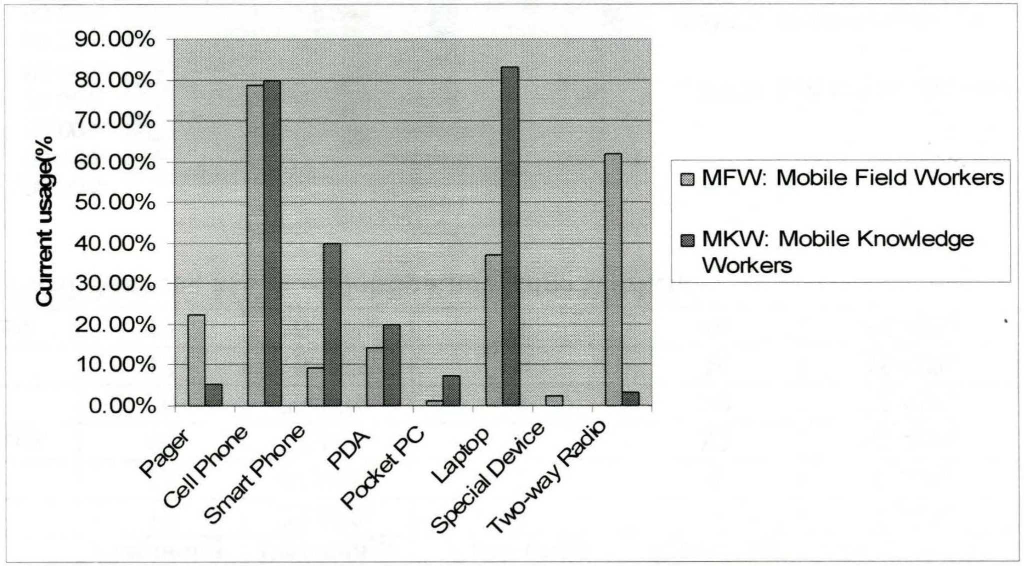


Figure 15. Current Usage of Mobile Devices

Table 44: Network Usage

Network	MFW[†] (N=84)			MKW[†] (N=95)		
	Frequency	Percentage	Rank order	Frequency	Percentage	Rank order
Pager network	19	22.60%	4	5	5.30%	5
Two way radio	52	61.90%	2	4	4.20%	6
Cell phone network	66	78.60%	1	83	87.40%	1
WiFi	20	23.80%	3	69	72.60%	2
Email network	13	15.50%	6	34	35.80%	4
Fixed line network	17	20.20%	5	46	48.40%	3

†: MFW – Mobile Field Workers; MKW – Mobile Knowledge Workers

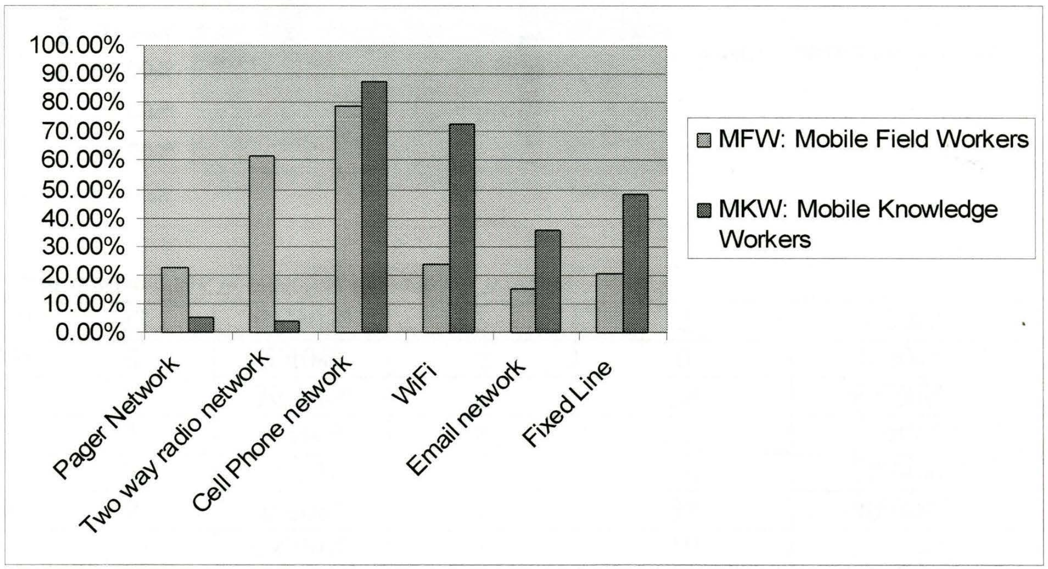


Figure 16: Current Network Usage

Table 45: Comparison of Current Usage of Mobile Support Between MFW and MKW†

N=179	MFW (N=84)		MKW (N=95)		Mean	
	Mean	Rank order	Mean	Rank order	Differences	t-test
1.Mobile Voice Communication	5.69	1	5.31	1	0.38	0.141(ns)
2.Mobile Text Messaging	3.51	6	3.61	4	-0.1	0.779(ns)
3.Mobile Notification	4.45	3	3.00	5	1.45	0.000(***)
4.Mobile Information Searching	2.08	11	3.75	3	-1.67	0.000(***)
5.Mobile Offline Transaction Processing	2.46	7	1.27	11	1.19	0.000(***)
6.Mobile Online Transaction Processing	2.33	10	2.37	6	-0.04	0.901(ns)
7.Location Tracking	3.70	5	1.55	10	2.15	0.000(***)
8.Navigation	2.75	9	1.90	7	0.85	0.007(**)
9.Mobile Batch Mode Job Dispatching	4.12	4	1.61	9	2.51	0.000(***)
10.Mobile Real time Job Dispatching	5.06	2	1.80	8	3.26	0.000(***)
11.Mobile Office	2.39	8	4.18	2	-1.79	0.000(***)

† MFW – Mobile Field Workers; MKW – Mobile Knowledge Workers
ns: non-significant; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

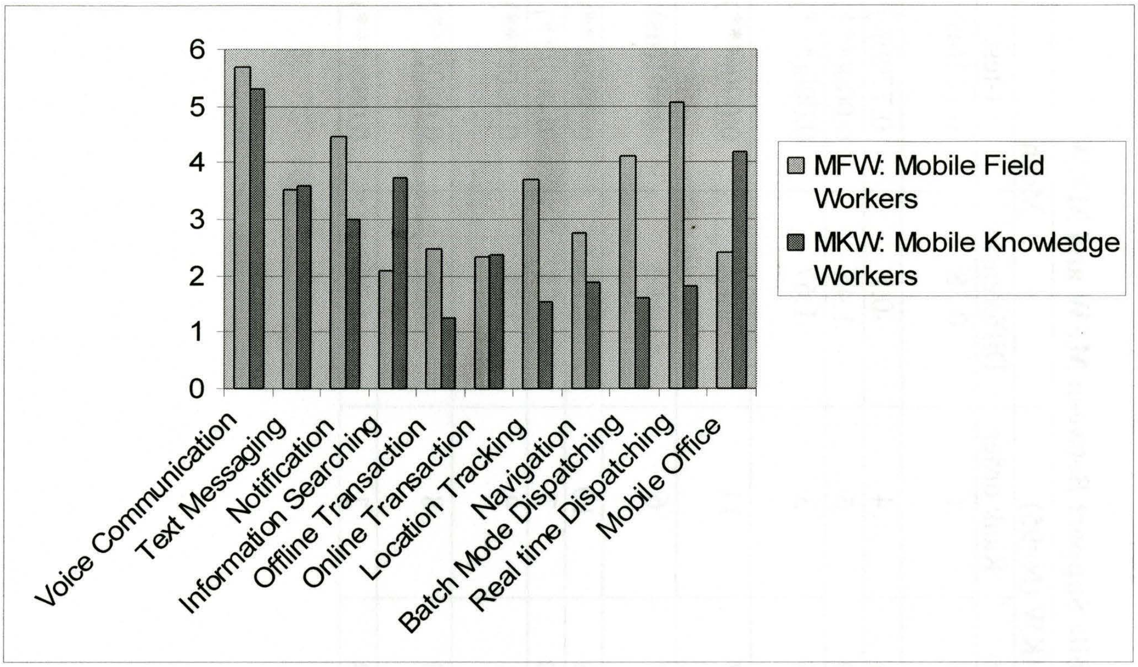


Figure 17: Comparison of Current Usage of Mobile Support between MFW and MKW

The comparisons of perceived usefulness of the eleven typical mobile functions between mobile knowledge workers and field workers are summarized below in Table 46 and Figure 18. Table 46 also shows the rank order and t-tests of differences from a neutral value of 4.0 and mean differences between mobile field workers and mobile knowledge workers for the perceived usefulness of mobile technology functions. We find that:

(1) For perceived usefulness of mobile voice communication and text messaging, there are no differences between mobile knowledge workers and field workers.

(2) For mobile job dispatching (including both batch mode job dispatching and real time job dispatching), field workers perceive these to be more useful than do mobile knowledge workers. Usually field worker tasks are assigned by their dispatchers, while mobile knowledge workers arrange their own work.

(3) Location tracking and navigation are perceived to be more useful by field workers than by mobile knowledge workers. This is because field worker tasks are more location sensitive than are mobile knowledge worker tasks.

(4) Mobile notification is perceived by field workers to be more useful than it is by mobile knowledge workers. This is because the degree of time criticality for field workers is higher than it is for mobile knowledge workers.

(5) Mobile information searching and mobile office functions are perceived to be more useful by mobile knowledge workers than by field workers. Mobile knowledge workers need these functions to deal with complex tasks.

(6) Offline transaction processing is perceived by field workers to be more useful than for mobile knowledge workers, but there is no difference in the perceived usefulness of online transactions between the two classes.

6.4.4 Intention to Use Mobile Functions

The comparisons of intention to use the eleven typical mobile functions are summarized in Table 47 and Figure 19. Table 47 also shows the rank order and the t-test of differences from a neutral value of 4.0 and mean differences between mobile field workers and mobile knowledge workers for intention to use mobile technology functions. The pattern of these differences of intention to use is similar to the differences of perceived usefulness shown in Table 46 and Figure 18.

6.4.5 Gap between Current Usage and Intention to Use Mobile Functions

The gap between current usage and intention to use for the eleven typical mobile functions in terms of mobile knowledge workers and field workers is shown in Table 48 and Figures 20, 21. Table 48 also shows the rank order of the gap. We found that:

For field workers, there are no gaps between the current usage of and intention to use mobile voice communication, mobile text messaging, and real time job dispatching. There are gaps for other mobile functions. For mobile knowledge workers, there are gaps for all mobile functions.

The biggest gap for both mobile knowledge workers and field workers is navigation. This shows that navigation has a great potential market. Mobile knowledge workers prefer more mobile support for all the technology functions they use. But field workers tend to focus more on transaction processing and job dispatching support.

Table 46: Comparison of Perceived Usefulness of Mobile Support between MFW and MKW†

N=179	MFW (N=84)		MKW (N=95)		Mean differences	Sig.
	Mean (t-test: difference from neutral value 4)	Rank order	Mean (t-test: difference from neutral value 4)	Rank order		
1.Mobile Voice Communication	5.59 (0.000)	1	5.71 (0.000)	1	-0.12	0.619(ns)
2.Mobile Text Messaging	3.80 (0.429)	7	4.34 (0.126)	5	-0.54	0.106(ns)
3.Mobile Notification	5.05 (0.000)	3	4.06 (0.787)	4	0.99	0.002(**)
4.Mobile Information Searching	2.84 (0.000)	10	4.93 (0.000)	3	-2.09	0.000(***)
5.Mobile Offline Transaction Processing	3.48 (0.04)	8	2.14 (0.000)	11	1.34	0.000(***)
6.Mobile Online Transaction Processing	3.08 (0.000)	9	3.38 (0.008)	7	-0.3	0.374(ns)
7.Location Tracking	4.52 (0.035)	6	2.19 (0.000)	9	2.33	0.000(***)
8.Navigation	5.03 (0.000)	4	3.51 (0.026)	6	1.52	0.000(***)
9.Mobile Batch Mode Job Dispatching	5.02 (0.000)	5	2.24 (0.000)	10	2.78	0.000(***)
10.Mobile Real time Job Dispatching	5.39 (0.000)	2	2.81 (0.000)	8	2.58	0.000(***)
11.Mobile Office	2.51 (0.000)	11	5.18 (0000)	2	-2.67	0.000(***)

†: MFW – Mobile Field Workers; MKW – Mobile Knowledge Workers
ns: non-significant ; *: p<0.05 ; **: p<0.01 ;***: p<0.001

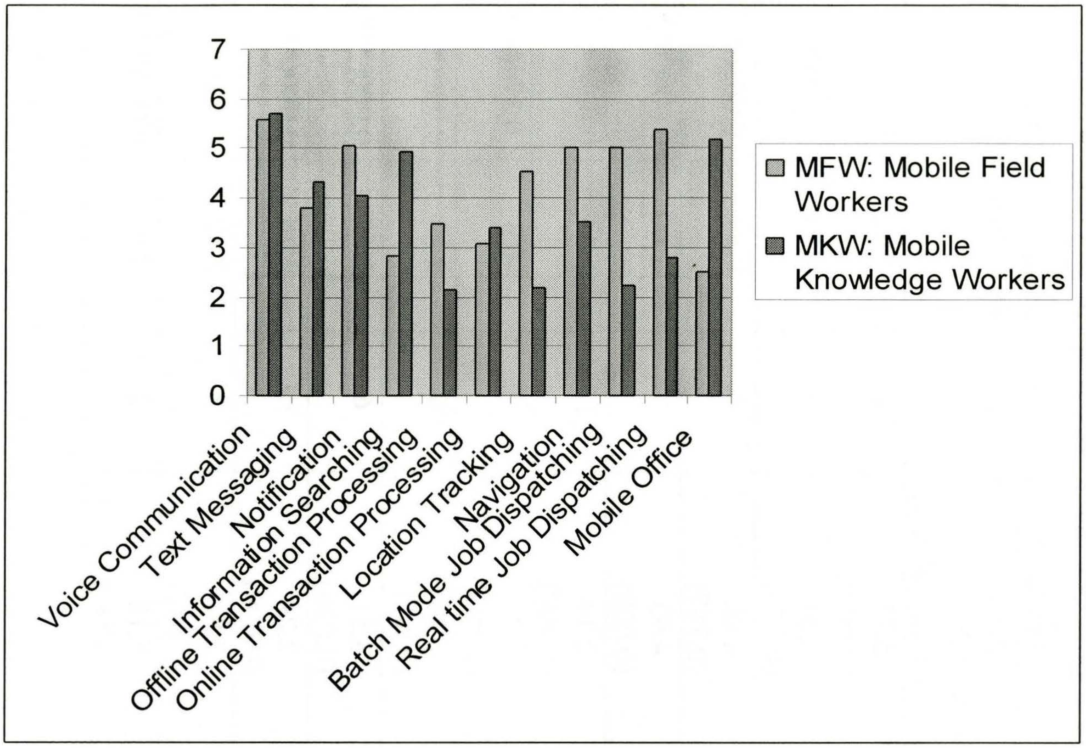


Figure 18: Comparison of Perceived Usefulness of Mobile Support between MFW and MKW

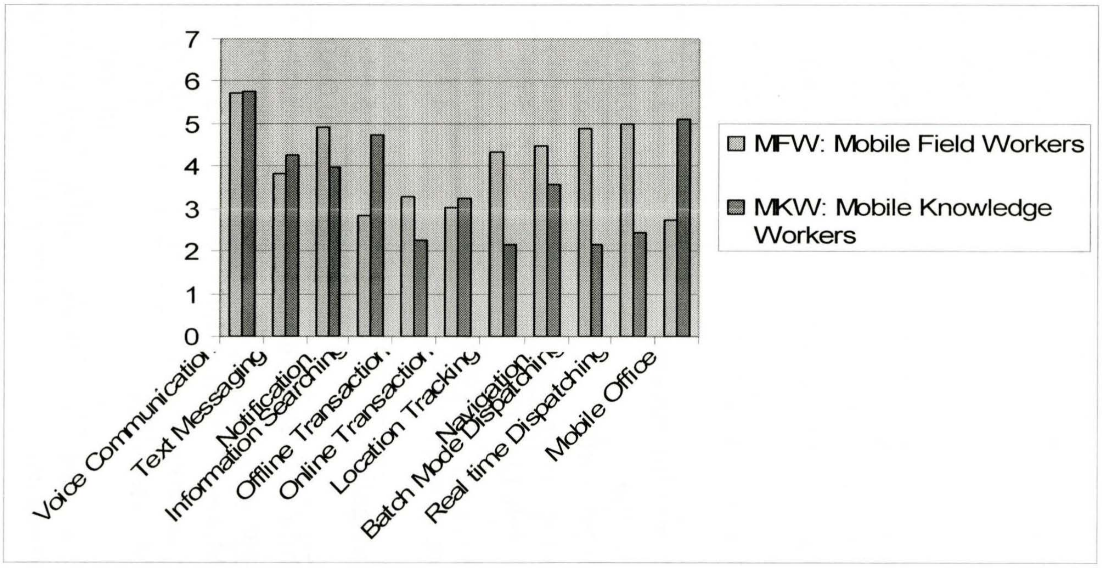


Figure 19: Comparison of Intention to Use Mobile Support between MFW and MKW

Table 47: Comparison of Intention to Use Mobile Support between MFW and MKW†

N=179	MFW(N=84)		MKW (N=95)		Differences	t-test: mean differences
	Mean (t-test: difference from neutral value 4)	Rank order	Mean (t-test: difference from neutral value 4)	Rank order		
1.Mobile Voice Communication	5.72 (0.000)	1	5.77 (.000)	1	-0.05	0.824(ns)
2.Mobile Text Messaging	3.84 (0.545)	7	4.26 (0.267)	4	-0.42	0.232(ns)
3.Mobile Notification	4.92 (.000)	3	3.99 (0.961)	5	0.93	0.004(**)
4.Mobile Information Searching	2.83 (.000)	10	4.74 (0.001)	3	-1.91	0.000(***)
5.Mobile Offline Transaction Processing	3.27 (0.006)	8	2.26 (.000)	9	1.01	0.002(**)
6.Mobile Online Transaction Processing	3.04 (.000)	9	3.25 (0.001)	7	-0.21	0.532(ns)
7.Location Tracking	4.33 (0.211)	6	2.16 (.000)	10	2.17	0.000(***)
8.Navigation	4.50 (0.045)	5	3.56 (0.040)	6	0.94	0.004(**)
9.Mobile Batch Mode Job Dispatching	4.87 (0.001)	4	2.15 (.000)	11	2.72	0.000(***)
10.Mobile Real time Job Dispatching	4.99 (.000)	2	2.45 (.000)	8	2.54	0.000(***)
11.Mobile Office	2.72 (.000)	11	5.10 (.000)	2	-2.38	0.000(***)

†: MFW – Mobile Field Workers; MKW – Mobile Knowledge Workers
ns: non-significant ; *: p<0.05 ; **: p<0.01 ; ***: p<0.001

Table 48: Gap between Current Usage and Intention to Use Mobile Support

N=179	MFW†					MKW†				
	Current Usage	Intention to use	Gap	Sig.	Rank order	Current Usage	Intention to use	Gap	Sig.	Rank order
1.Mobile Voice Communication	5.69	5.72	0.03	0.840 (ns)	9	5.31	5.77	0.46	0.000 (***)	11
2.Mobile Text Messaging	3.51	3.84	0.33	0.098 (ns)	9	3.61	4.26	0.65	0.000 (***)	7
3.Mobile Notification	4.45	4.92	0.47	0.038 (*)	7	3.00	3.99	0.99	0.000 (***)	2
4.Mobile Information Searching	2.08	2.83	0.75	0.000 (***)	3	3.75	4.74	0.99	0.000 (***)	2
5.Mobile Offline Transaction Processing	2.46	3.27	0.81	0.000 (***)	2	1.27	2.26	0.99	0.000 (***)	2
6.Mobile Online Transaction Processing	2.33	3.04	0.71	0.000 (***)	5	2.37	3.25	0.88	0.000 (***)	6
7.Location Tracking	3.70	4.33	0.63	0.014 (*)	6	1.55	2.16	0.61	0.000 (***)	9
8.Navigation	2.75	4.50	1.75	0.000 (***)	1	1.90	3.56	1.66	0.000 (***)	1
9.Mobile Batch Mode Job Dispatching	4.12	4.87	0.75	0.004 (**)	3	1.61	2.15	0.54	0.000 (***)	10
10.Mobile Real time Job Dispatching	5.06	4.99	-0.07	0.779 (ns)	9	1.80	2.45	0.65	0.000 (***)	7
11.Mobile Office	2.39	2.72	0.33	0.011 (*)	8	4.18	5.10	0.92	0.000 (***)	5

†: MFW – Mobile Field Workers; MKW – Mobile Knowledge Workers
ns: non-significant; *: p<0.05; **: p<0.01; ***: p<0.001

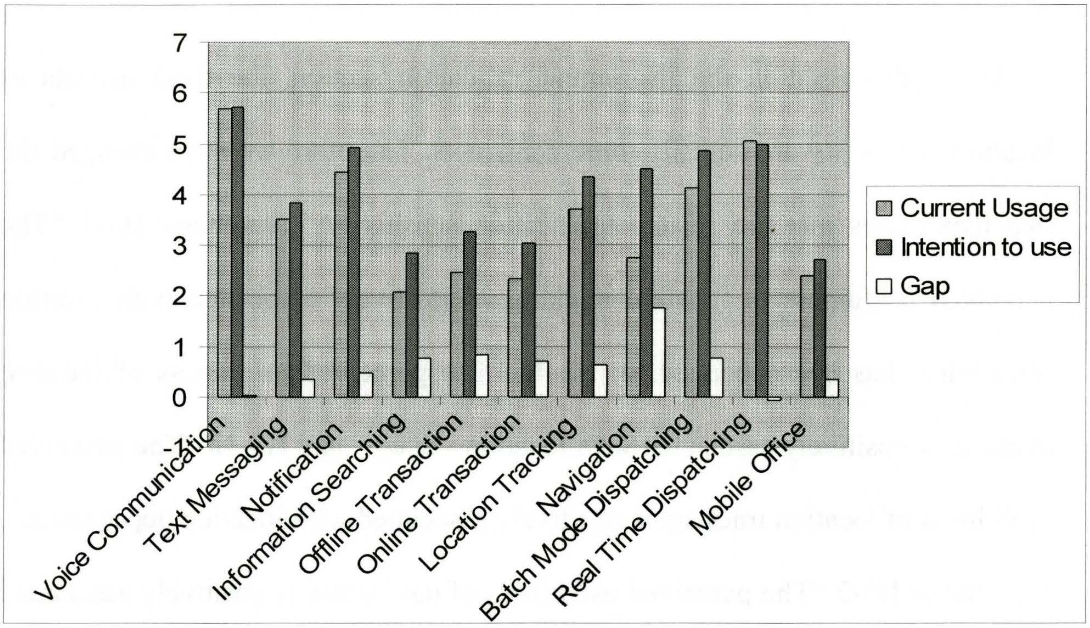


Figure 20: Gap between Current Usage and Intention to Use Mobile Support for Field Workers

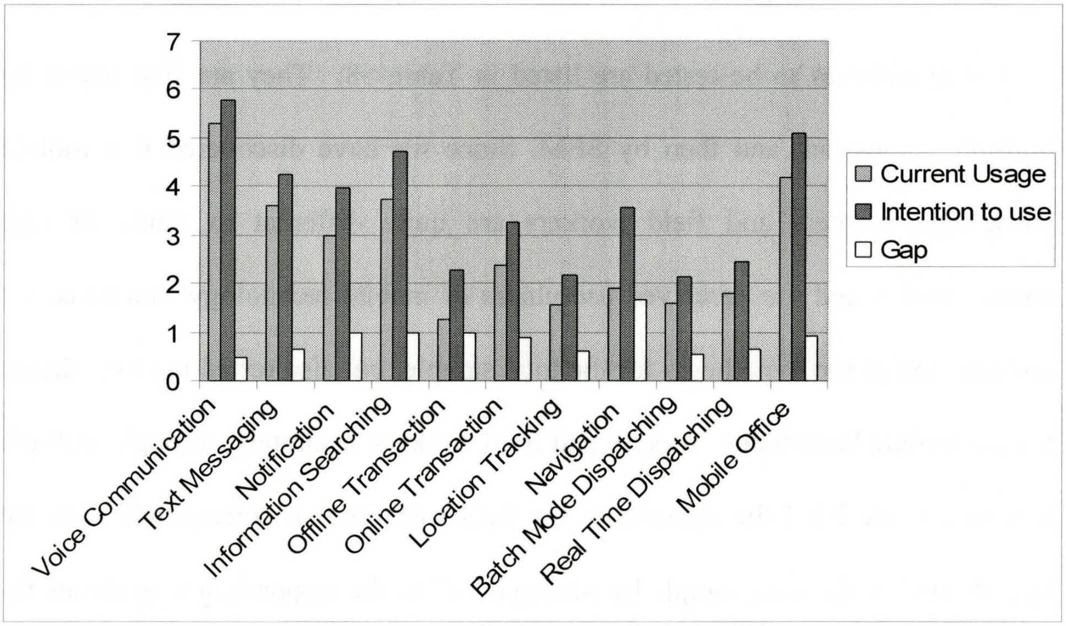


Figure 21: Gap between Current Usage and Intention to Use Mobile Support for Mobile Knowledge Workers

6.5 Hypotheses Tests

As we discussed in the instrument validation section, the three aspects of location sensitivity are actually three constructs. Therefore we have changed the two hypotheses that are related to location sensitivity: Hypothesis H3-1 "The perceived usefulness of location tracking is positively associated with location sensitivity" has been changed to: H3-1a "The perceived usefulness of location tracking is positively associated with location variety" and H3-1b "The perceived usefulness of location tracking is positively associated with location dependence". Hypothesis H3-2 "The perceived usefulness of navigation is positively associated with location sensitivity" is changed to H3-2 "The perceived usefulness of navigation is positively associated with location variety".

The hypotheses to be tested are listed in Table 58. They are first tested by multiple regression, and then by SEM. Since we have discovered that mobile knowledge workers and field workers are quite different in terms of task characteristics and the perceived usefulness of mobile technology functions, we not only tested the hypotheses for the total sample, but also tested the hypotheses for the mobile knowledge workers and field workers separately, through multiple regression. We label the hypotheses for field workers that corresponds with the hypotheses for the total sample by adding a "-f" to the responding hypotheses for total sample, as shown in Table 53. Accordingly we label the hypotheses for mobile knowledge workers that corresponds with hypotheses for the total sample by adding a "-k" to the corresponding hypotheses for the total sample, as shown in Table 54.

6.5.1 Multiple Linear Regressions

6.5.1.1 Regressions for the Total Sample

The correlations between dimensions of mobile tasks and mobile functions are shown in table 49. It is clear that most of the correlations agree with our hypotheses.

Regression analyses were conducted for eleven separate models. Each model has the perceived usefulness of one of the eleven typical mobile functions as the dependent variable, and uses some of the task characteristics as independent variables. The regression coefficient βs corresponding to the hypotheses are summarized in Table 50 and R^2 is reported in Table 51.

The regressions of intention to use on perceived usefulness for the eleven typical mobile technology functions are shown in Table 52. The results show that hypothesis H5 is supported.

6.5.1.2 Regressions for Field Workers Sample

The same multiple regressions analyses were conducted for field worker data. The results for the regression of perceived usefulness of mobile technology functions on task characteristics are summarized in Table 53. For field workers, the perceived usefulness of location tracking is significantly and positively associated with location variety. The perceived usefulness of mobile notification is significantly and positively associated with time criticality. That is, hypotheses H3-1a-f and H4-1-f are supported. All the other hypotheses for field workers are not supported. The results of the regressions of intention to use on perceived usefulness are shown in Appendix C. They show that hypothesis H5-f is supported for the sample of field workers.

6.5.1.3 Regressions for Mobile Knowledge Workers Sample

The same multiple regression analyses were conducted for the sample from mobile knowledge workers. The results for the perceived usefulness of mobile technology functions on task characteristics are summarized in Table 54. For mobile knowledge workers, the perceived usefulness of mobile notification is significantly and positively associated with time criticality. That is, only hypothesis H4-1-k was supported. All the other hypotheses for mobile knowledge workers were not supported.

The results from regressions of intention to use on perceived usefulness are shown in Appendix D. They show that hypothesis H5-k is supported for the sample of mobile knowledge workers.

Table 49: Correlations Between Task Characteristic Dimensions and Perceived Usefulness of Mobile Support

	Task Complexity	Task Interdependence	Time Criticality	Location Variety	Location Dependence
Voice Communication	**H1-1a** Ns	**H2-1a** ns	0.206(**)	0.281(***)	ns
Text Messaging	**H1-1b** Ns	**H2-1b** ns	ns	ns	ns
Notification	-0.163(*)	ns	**H4-1** 0.303(***)	0.278(***)	0.272(***)
Information Searching	**H1-2** 0.302(***)	ns	-0.158(*)	ns	-0.171(*)
Offline Transactions	**H1-3a** -0.257(**)	ns	ns	0.256(**)	0.342(***)
Online Transactions	**H1-3b** Ns	ns	ns	ns	ns
Location Tracking	-0.340(***)	ns	**H4-2** 0.342(***)	**H3-1a** 0.296(***)	**H3-1b** 0.407(***)
Navigation	-0.149(*)	ns	0.266(**)	**H3-2** 0.206(**)	0.337(***)
Batch Mode Job Dispatching	**H1-4a** -0.443(***)	ns	**H4-3a** 0.283(**)	0.354(***)	0.278(***)
Real Time Job Dispatching	**H1-4b** -0.341(***)	ns	**H4-3b** 0.302(**)	0.347(***)	0.324(***)
Mobile Office Functions	**H1-5** 0.319(***)	.197(**)	-0.188(*)	ns	-0.190(*)

N=179

*: p< 0.05; **: p< 0.01; ***: p<0.001

Table 50: Regression Coefficients Corresponding to Hypotheses for Total Sample

Hypotheses		β
H1-1a	Task complexity -> Mobile voice communication.	0.078(ns)
H1-1b	Task complexity -> Mobile text messaging	-0.005(ns)
H1-2	Task complexity -> Mobile information searching	0.302(***)
H1-3a	Task complexity -> Mobile offline transaction processing	-0.257 (**)
H1-3b	Task complexity -> Mobile online transaction processing	0.060(ns)
H1-4a	Task complexity -> Batch-mode mobile job dispatching	-0.427 (***)
H1-4b	Task complexity -> Real time mobile job dispatching	-0.320(***)
H1-5	Task complexity -> Mobile office	0.319(***)
H2-1a	Task interdependence -> Mobile voice communication	-0.021(ns)
H2-1b	Task interdependence -> Mobile text messaging	0.054(ns)
H3-1a	Location variety -> Location tracking	0.188(**)
H3-1b	Location dependence -> Location tracking	0.305 (***)
H3-2	Location variety -> Navigation	0.206(**)
H4-1	Time criticality -> Mobile notification	0.278 (***)
H4-2	Time criticality -> Location tracking	0.159 (**)
H4-3a	Time criticality -> Batch mode mobile job dispatching	0.114(ns)
H4-3b	Time criticality -> Real time mobile job dispatching	0.148(*)

β: Standardized regression coefficients
ns: non significant; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

Table 51: Report of R^2 from Linear Regression

The Perceived Usefulness of	R^2
Voice Communication	0.01
Text Messaging	0.00
Notification	0.08
Information Searching	0.09
Offline Transaction Processing	0.07
Online Transaction Processing	0.00
Location Tracking	0.22
Navigation	0.04
Batch Mode Job Dispatching	0.21
Real Time Job Dispatching	0.14
Mobile Office	0.10

Table 52: Regression of Intention to Use on Perceived Usefulness for Total Sample

Dependent Variable	Independent Variable	R^2	Β
Intention to use Mobile Voice Communication	Perceived Usefulness of Mobile Voice Communication	0.69(***)	0.83(***)
Intention to use Mobile Text Messaging	Perceived Usefulness of Mobile Text Messaging	0.66(***)	0.81(***)
Intention to use Mobile Notification	Perceived Usefulness of Mobile Notification	0.74(***)	0.86(***)
Intention to use Mobile Information Searching	Perceived Usefulness of Mobile Information Searching	0.71(***)	0.85(***)
Intention to use Mobile Off-line Transaction Processing	Perceived Usefulness of Mobile Off-line Transaction Processing	0.67(***)	0.82(***)
Intention to use Mobile Online Transaction Processing	Perceived Usefulness of Mobile Online Transaction Processing	0.71(***)	0.85(***)
Intention to use Location Tracking	Perceived Usefulness of Location Tracking	0.77(***)	0.88(***)
Intention to use Navigation	Perceived Usefulness of Navigation	0.73(***)	0.85(***)
Intention to use Batch Mode Mobile Job Dispatching	Perceived Usefulness of Batch Mode Mobile Job Dispatching	0.80(***)	0.90(***)
Intention to use Real Time Mobile Job Dispatching	Perceived Usefulness of Real Time Mobile Job Dispatching	0.71(***)	0.84(***)
Intention to use Mobile Office	Perceived Usefulness of Mobile Office	0.90(***)	0.95(***)

β: Standardized regression coefficients
***: $p<0.001$

Table 53: Regression Coefficients Corresponding to Hypotheses for Field Worker Sample

Hypotheses		Sig. of regression	β
H1-1a-f	Task complexity -> Mobile voice communication.	0.667(ns)	0.061(ns)
H1-1b-f	Task complexity -> Mobile text messaging	0.203(ns)	0.034(ns)
H1-2-f	Task complexity -> Mobile information searching	0.318(ns)	0.110(ns)
H1-3a-f	Task complexity -> Mobile offline transaction processing	0.511(ns)	-0.073 (ns)
H1-3b-f	Task complexity -> Mobile online transaction processing	0.107(ns)	0.177(ns)
H1-4a-f	Task complexity -> Batch-mode mobile job dispatching	0.416(ns)	-0.076(ns)
H1-4b-f	Task complexity -> Real time mobile job dispatching	0.208(ns)	0.192(ns)
H1-5-f	Task complexity -> Mobile office	0.817(ns)	0.026(ns)
H2-1a-f	Task interdependence -> Mobile voice communication	0.667(ns)	0.069(ns)
H2-1b-f	Task interdependence -> Mobile text messaging	0.203(ns)	0.188(ns)
H3-1a-f	Location variety -> Location tracking	0.003(**)	0.212(*)
H3-1b-f	Location dependence -> Location tracking	0.003(**)	0.167 (ns)
H3-2-f	Location variety -> Navigation	0.317(ns)	0.111(ns)
H4-1-f	Time criticality -> Mobile notification	0.008(**)	0.288 (**)
H4-2-f	Time criticality -> Location tracking	0.003(**)	.210 (ns)
H4-3a-f	Time criticality -> Batch mode mobile job dispatching	0.416(ns)	0.116(ns)
H4-3b-f	Time criticality -> Real time mobile job dispatching	0.208(ns)	0.063(ns)

β: Standardized regression coefficients
ns: non significant; *: $p<0.05$; **: $p<0.01$

Table 54: Regression Coefficients Corresponding to Hypotheses for Mobile Knowledge Workers Sample

Hypotheses		Sig. of regression	β
H1-1a-k	Task complexity -> Mobile voice communication.	0.403(ns)	0.090(ns)
H1-1b-k	Task complexity -> Mobile text messaging	0.086(ns)	-0.171(ns)
H1-2-k	Task complexity -> Mobile information searching	0.863(ns)	-0.018(ns)
H1-3a-k	Task complexity -> Mobile offline transaction processing	0.240(ns)	-0.122 (ns)
H1-3b-k	Task complexity -> Mobile online transaction processing	0.316(ns)	-0.104(ns)
H1-4a-k	Task complexity -> Batch-mode mobile job dispatching	0.052(ns)	-0.231(*)
H1-4b-k	Task complexity -> Real time mobile job dispatching	0.413(ns)	-0.100(ns)
H1-5-k	Task complexity -> Mobile office	0.790(ns)	-0.028(ns)
H2-1a-k	Task interdependence -> Mobile voice communication	0.403(ns)	-0.134(ns)
H2-1b-k	Task interdependence -> Mobile text messaging	0.086(ns)	-0.111(ns)
H3-1a-k	Location variety -> Location tracking	0.298(ns)	0.139(ns)
H3-1b-k	Location dependence -> Location tracking	0.298(ns)	-0.011 (ns)
H3-2-k	Location variety -> Navigation	0.365(ns)	0.094(ns)
H4-1-k	Time criticality -> Mobile notification	0.026(*)	0.229 (*)
H4-2-k	Time criticality -> Location tracking	0.298(ns)	0.122 (ns)
H4-3a-k	Time criticality -> Batch mode mobile job dispatching	0.052(ns)	0.088(ns)
H4-3b-k	Time criticality -> Real time mobile job dispatching	0.413(ns)	0.092(ns)

β: Standardized regression coefficients
ns: non significant; *: $p<0.05$

6.5.2 SEM

SEM was used to test the complete hypothesized model. Since relationships between perceived usefulness and intention to use were not the focus of this study, and there are many studies that have confirmed these relationships, we did not include the eleven intention to use constructs in the tested model. We included the perceived usefulness of the eleven typical mobile functions and five constructs of task characteristics (task complexity, task interdependence, time criticality, location variety, and location dependence) in the model, as shown in Figure 22.

We built paths in the model based on the hypotheses. The results of the Structuring Sequential Models are summarized in table 55. The path coefficients are provided in table 56 and shown in Figure 22. R^2 is reported in Table 57.

Table 55: Fit Indices for the Structural Model

Model	$\chi 2$	df	X2/df	RMSEA	CFI	NNFI
Threshold			<=0.03	<=0.10	>=0.90	>=0.90
Hypothesized model	3032.00	1507	2.01	0.073	0.91	0.91

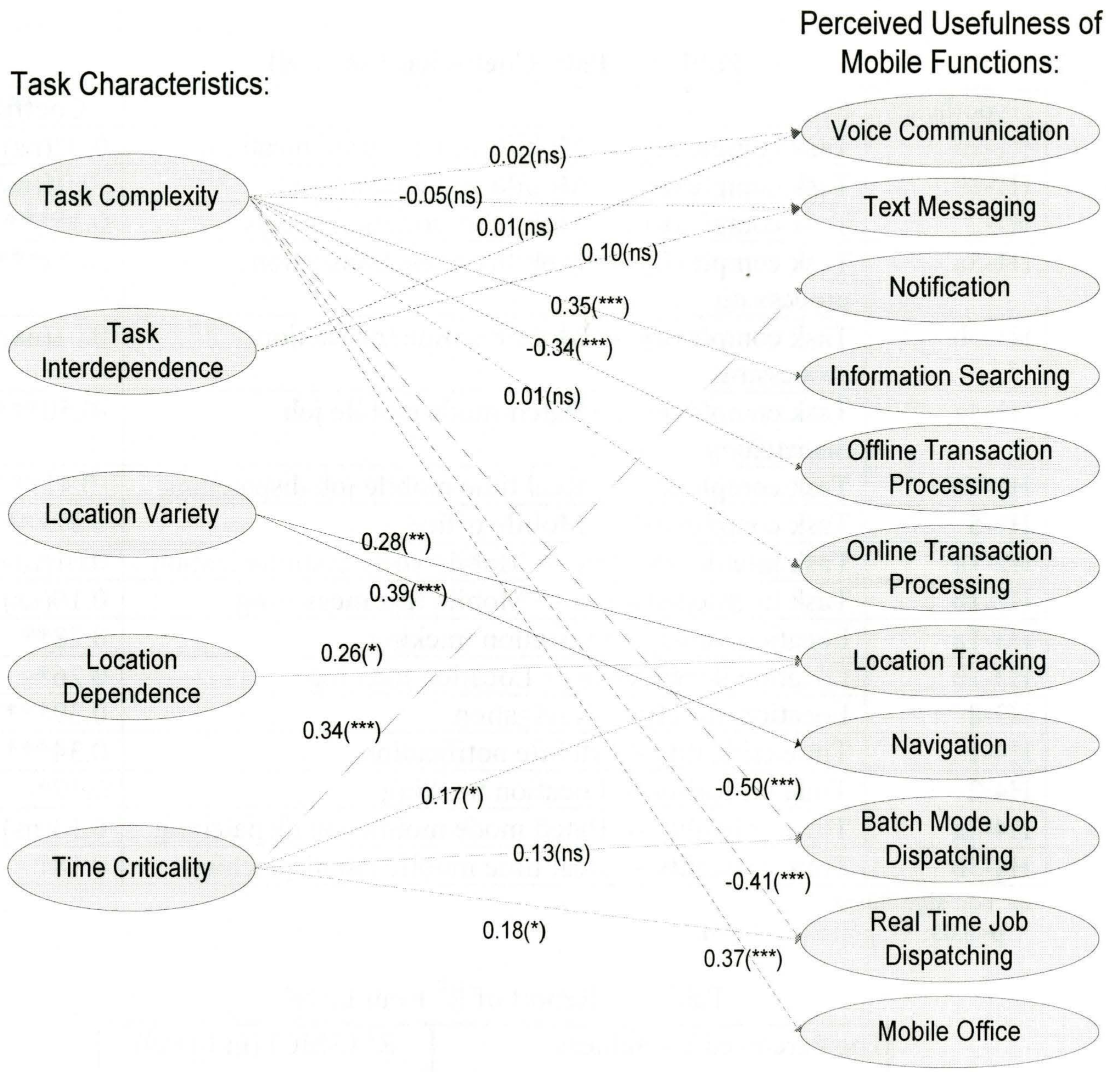


Figure 22: Revised Hypothesized Model

Table 56: Path Coefficients (Lisrel)

Hypotheses	Path	Coefficient
H1-1a	Task complexity -> Mobile voice communication.	0.02(ns)
H1-1b	Task complexity -> Mobile text messaging	-0.05(ns)
H1-2	Task complexity -> Mobile information access	0.35***
H1-3a	Task complexity -> Mobile offline transaction processing	-0.34***
H1-3b	Task complexity -> Mobile online transaction processing	0.01(ns)
H1-4a	Task complexity -> Batch-mode mobile job dispatching	-0.50***
H1-4b	Task complexity -> Real time mobile job dispatching	-0.41***
H1-5	Task complexity -> Mobile office	0.37***
H2-1a	Task interdependence -> Mobile voice communication	0.01(ns)
H2-1b	Task interdependence -> Mobile text messaging	0.10(ns)
H3-1a	Location variety -> Location tracking	0.28**
H3-1b	Location dependence -> Location tracking	0.26*
H3-2	Location variety -> Navigation	0.39***
H4-1	Time criticality -> Mobile notification	0.34***
H4-2	Time criticality -> Location tracking	0.17*
H4-3a	Time criticality -> Batch mode mobile job dispatching	0.13(ns)
H4-3b	Time criticality -> Real time mobile job dispatching	0.18*

ns: non-significant
*: $p<0.05$; **: $p<0.01$; $p<0.001$

Table 57: Report of R^2 from Lisrel

The Perceived Usefulness	R^2 (SMC) (in Lisrel)
Voice Communication	0.00
Text Messaging	0.01
Notification	0.11
Information Searching	0.12
Offline Transaction Processing	0.11
Online Transaction Processing	0.00
Location Tracking	0.31
Navigation	0.15
Batch Mode Job Dispatching	0.30
Real Time Job Dispatching	0.24
Mobile Office	0.13

6.5.3 Discussion of Hypothesis Tests for Total Sample

Tables 50 and 56 show the results of each hypothesis testing, as shown in Table 58. The results of the study generally demonstrated that the variety of the nature of mobile work determines or affects the variety of the perceived usefulness of mobile technology functions.

The following conclusions are based on hypothesis tests on the complete sample:

Hypothesis H1-2 "The perceived usefulness of mobile information searching is positively associated with task complexity" is supported.

Hypothesis H1-3a "The perceived usefulness of mobile offline transaction processing is negatively associated with task complexity" is supported.

Hypothesis H1-4a "The perceived usefulness of batch mode mobile job dispatching is negatively associated with task complexity" is supported.

Hypothesis H1-4b "The perceived usefulness of real time mobile job dispatching is negatively associated with task complexity" is supported.

Support for the above four hypotheses is generally consistent with Gebauer and Shaw's (2004) study. Their study found that workers performing highly structured tasks tend to use mobile business applications for data processing, and workers performing unstructured tasks tend to use mobile business applications to access information. The data processing application in Gebauer and Shaw's (2004) study corresponds with mobile online transaction processing in this study.

Accessing information in Gebauer and Shaw's (2004) study corresponds with mobile information searching in this study.

Table 58: Results of Hypothesis Tests for Total Sample

	Hypotheses	Supported?
H1-1a	The perceived usefulness of mobile voice communication is positively associated with task complexity.	No
H1-1b	The perceived usefulness of mobile text messaging is positively associated with task complexity.	No
H1-2	The perceived usefulness of mobile information searching is positively associated with task complexity.	Yes
H1-3a	The perceived usefulness of mobile offline transaction processing is negatively associated with task complexity.	Yes
H1-3b	The perceived usefulness of mobile online transaction processing is negatively associated with task complexity.	No
H1-4a	The perceived usefulness of batch-mode mobile job dispatching is negatively associated with task complexity.	Yes
H1-4b	The perceived usefulness of real time mobile job dispatching is negatively associated with task complexity.	Yes
H1-5	The perceived usefulness of mobile office is positively associated with task complexity.	Yes
H2-1a	The perceived usefulness of mobile voice communication is positively associated with task interdependence.	No
H2-1b	The perceived usefulness of mobile text messaging is positively associated with task interdependence.	No
H3-1a	The perceived usefulness of location tracking is positively associated with location variety.	Yes
H3-1b	The perceived usefulness of location tracking is positively associated with location dependence.	Yes
H3-2	The perceived usefulness of navigation is positively associated with location variety.	Yes
H4-1	The perceived usefulness of a mobile notification is positively associated with time criticality.	Yes
H4-2	The perceived usefulness of location tracking is positively associated with time criticality.	Yes
H4-3a	The perceived usefulness of batch mode mobile job dispatching is positively associated with time criticality.	No
H4-3b	The perceived usefulness of real time mobile job dispatching is positively associated with time criticality.	Yes

Hypothesis H1-5 "The perceived usefulness of mobile office is positively associated with task complexity" is supported.

Mobile office functions are used to deal with complex tasks such as: creating correspondence, doing customer proposals, presentations to customers, and writing sales analysis reports. These tasks are complex because their inputs and outputs tend to change case by case.

Hypothesis H4-1 "The perceived usefulness of mobile notification is positively associated with time criticality" is supported.

Support for hypothesis H4-1 is consistent with Gebauer and Shaw's (2004) study. Their study found that the use of mobile business applications is positively correlated with the perceived need to handle emergency situations. Specifically their study found evidence that users saw value in mobile applications for supporting emergency situations, by way of notification.

Hypothesis H4-2 "The perceived usefulness of location tracking is positively associated with time criticality" is supported.

In practice, there are three ways to locate or track mobile workers. The first is that the dispatcher can know the general whereabouts of the mobile workers through their work orders. The second is through mobile workers reporting their location in a certain time period, such as two hours. The third is by using GPS location tracking systems to track mobile workers. If time is not critical for performing tasks, dispatchers need only to use the first two ways to track mobile workers, as in the case of cable or phone maintenance. However, if time is very important for performing tasks, GSP location tracking systems are needed, as in the case of emergency services or taxi service.

Hypothesis H3-1a "The perceived usefulness of location tracking is positively associated with location variety" is supported.

The support of the above hypothesis is generally consistent with information processing theory. According to this theory, uncertainty leads to increased information needs. The higher location variety of mobile workers often involves a need to know their location, involving an increased reliance on location tracking systems to get the required information.

Hypothesis H3-1b "The perceived usefulness of location tracking is positively associated with location dependence" is supported.

The main benefit of location tracking is to know the current location of mobile workers. If the performance of mobile tasks requires location related information, then location tracking is critical, such as in the case of taxi or delivery service.

Hypothesis H3-2 "The perceived usefulness of navigation is positively associated with location variety" is supported.

The higher degree of location variety, the more possible the mobile workers are not familiar with their work locations and the routes to them. If mobile workers only need to go to several specific work locations, they would be very familiar with the locations and routes. So navigation is perceived more useful when the degree of location variety is higher.

Hypothesis H4-3b "The perceived usefulness of real time mobile job dispatching is positively associated with time criticality" is supported.

This confirms that real time mobile job dispatching is very important for time critical situations, and can greatly improve the productivity of taxi service as well as car towing services. If time critical performance of tasks is not important, such as home delivery, real time mobile job dispatching will not be important.

Hypothesis H1-1a "The perceived usefulness of mobile voice communication is positively associated with task complexity" is not supported.

This conflicts with previous studies. For example, Rice's (1992) study showed that use of information-rich media will be more strongly associated with positive performance effectiveness in unanalyzable task environments than in analyzable task environments. The information-rich media used in Rice's (1992) study was voice mail. Actually, voice communication is a more information-rich media than voice mail. This also conflicts with Gebauer and Shaw's (2004) study. Their study found that workers performing unstructured tasks tend to use mobile business applications for communication purposes.

The reason that hypothesis H1-1a is not supported may be because mobile voice communication is used for many purposes in mobile work. Besides discussing work and exchanging information, voice communication can be used for mobile notification in real time job dispatching. It is also used for location tracking and navigation. It can even be used for online transactions. That is, mobile voice communication can be used in situations with both high and low degrees of task complexity.

Hypothesis H2-1a "The perceived usefulness of mobile voice communication is positively associated with task interdependence" is not supported.

Hypothesis H2-1b "The perceived usefulness of mobile text messaging is positively associated with task interdependence" is not supported.

Both of the two task interdependence hypotheses H2-1a and H2-1b were not supported. In fact there are different kinds of interdependence: Interaction with people, and interdependence through information. Interaction with people can further be divided into: interaction with supervisor/dispatcher/headquarters, interaction with colleagues, and interaction with customers. These types of interdependencies differ, and the information involved and the frequencies of different interdependence are different, leading to different needs for mobile technology support. For example, if a mobile worker only needs to receive messages from his/her dispatcher and the contents of these messages are simple and the frequency is low, then mobile text messaging such as through a pager is enough support. If the contents are relatively complicated and interaction between mobile workers and their dispatchers is bi-directional, then mobile voice communication may be needed. However, in the existing literature, interdependence is considered and measured as one construct. This study also chose this way, and may be the reason why the two task interdependence related hypotheses H2-1a and H2-1b were not supported.

Hypothesis H1-1b "The perceived usefulness of mobile text messaging is positively associated with task complexity" is not supported.

Both of the two hypotheses H2-1b and H1-1b that are related with mobile text messaging were not supported. Notice that the mean of the perceived usefulness of mobile text messaging is not high, just around the neutral scale (4.0). For field workers, the mean was 3.80. For mobile knowledge workers, the mean was 4.34. Neither of the two means were significantly different from the neutral scale (4.0). This may be because typing text messages while on the move is not convenient. The small keyboard (or similar input devices) does not make mobile text messaging an easy or pleasant task. SMS is not popular in North America.

Hypothesis H1-4b "The perceived usefulness of mobile online transaction processing is positively associated with task complexity" is not supported.

The perceived usefulness of mobile online transaction processing is not related with any dimensions of task characteristics. Mobile knowledge workers and field workers indicated almost the same degree of perceived usefulness for mobile online transaction processing.

Hypothesis H4-3a "The perceived usefulness of batch mode mobile job dispatching is positively associated with time criticality" is not supported.

Although time is an important factor for batch mode mobile jobs, job assignments in batch mode job dispatching are usually to be finished within a day. Within a day, mobile workers do not feel that time is critical in performing the task. If a completion time deadline is within several hours, or even minutes, then batch mode mobile job dispatching cannot meet the requirements. In this case, real time mobile job dispatching is needed.

Hypothesis H5 "The perceived usefulness of mobile work support functions is positively associated with intention to use them" is supported. This confirms previous studies.

6.5.4 Discussion of Hypothesis Tests for Separate Samples of Mobile Knowledge Workers and Field Workers

Hypotheses were also tested for the separated sample of mobile knowledge workers and field workers, but most were not supported, as shown in Tables 61 and 62. The reason is that there are obvious differences between mobile knowledge workers and field workers in terms of both task characteristics (except location familiarity) and the perceived usefulness of mobile technology support functions (except mobile voice communication and mobile text messaging) (see Tables 39 and 44). For example, Figure 23 shows a scatter plot of perceived usefulness of location tracking and location dependence. The points for most mobile knowledge workers are in quadrant 1, while the points of most field workers are in quadrant 3. Of the 84 field workers, there were 61 whose location dependence scales were greater than or equal to 4.0 and there were 58 field workers whose perceived usefulness of location tracking scales were greater than or equal to 4.0. And there were 44 field workers whose location dependence and perceived usefulness of location tracking are greater than or equal to 4.0. Of the 95 mobile knowledge workers, there were 71 mobile knowledge workers whose location dependence measured less than or equal to 4.0 and there were 83 mobile knowledge workers whose perceived usefulness of location tracking were less than or equal to 4.0. And there were 63 mobile knowledge workers whose location dependence and perceived usefulness of location tracking are less than or equal to 4.0. Using the full population of mobile workers captures the variation of independent variable (such as location dependence) and dependent variable (such as location tracking), and their relationship is highly significant. However, the subgroups mobile knowledge worker and mobile field worker follow different distributions. Most knowledge worker data sample were near the lower left corner while most field worker data were near the top right corner (see Figure. 23). Between the two clusters, the relationships are weak. It is clear that neither of the subgroups can be treated as a random sub-sample of the parent sample, and we should not expect them to separately reveal the same conclusions as the total sample, and at the same significant level.

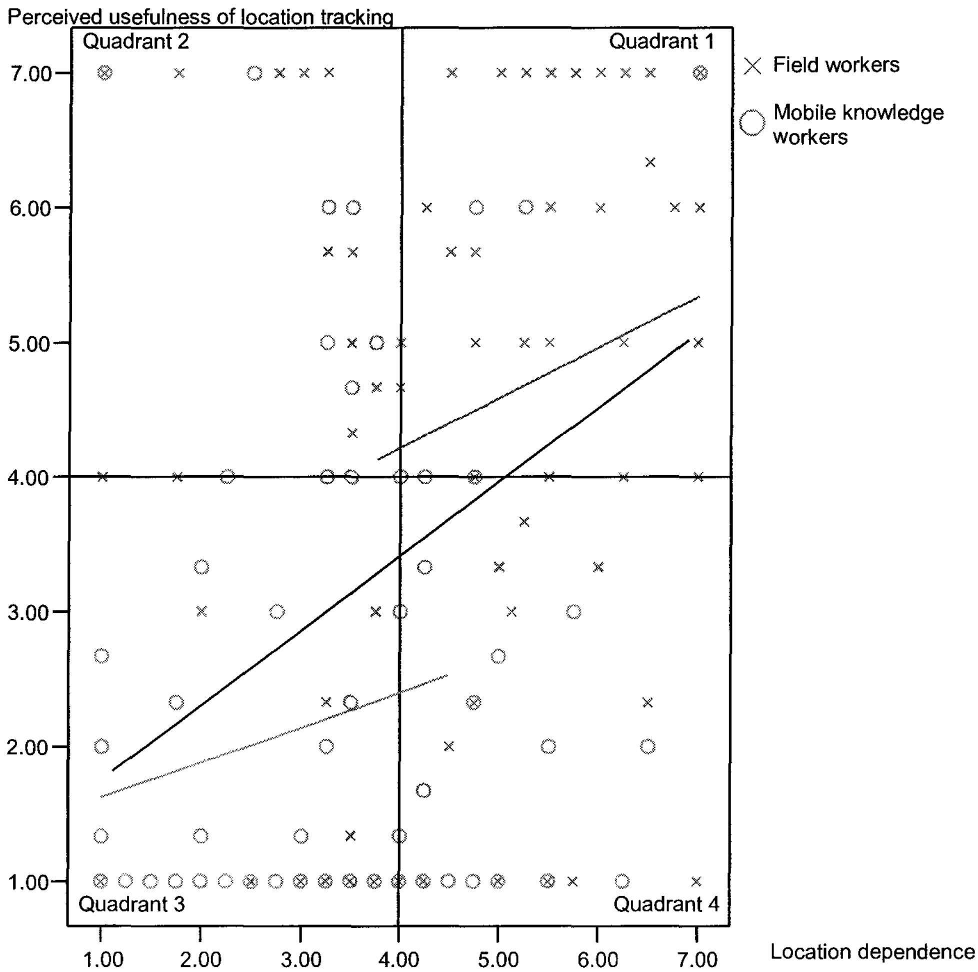


Figure 23: Scatter Plot of Perceived Usefulness of Location Tracking and Location Dependence

dependence scales were greater than or equal to 4.0 and there were 58 field workers whose perceived usefulness of location tracking scales were greater than or equal to 4.0. And there were 44 field workers whose location dependence and perceived usefulness of location tracking are greater than or equal to 4.0. Of the 95 mobile knowledge workers, there were 71 mobile knowledge workers whose location dependence measured less than or equal to 4.0 and there were 83 mobile knowledge workers whose perceived usefulness of location tracking were less than or equal to 4.0. And there were 63 mobile knowledge workers whose location dependence and perceived usefulness of location tracking are less than or equal to 4.0. Using the full population of mobile workers captures the variation of independent variable (such as location dependence) and dependent variable (such as location tracking), and their relationship is highly significant. However, the subgroups mobile knowledge worker and mobile field worker follow different distributions. Most knowledge worker data sample were near the lower left corner while most field worker data were near the top right corner (see Figure. 23). Between the two clusters, the relationships are weak. It is clear that neither of the subgroups can be treated as a random sub-sample of the parent sample, and we should not expect them to separately reveal the same conclusions as the total sample, and at the same significant level.

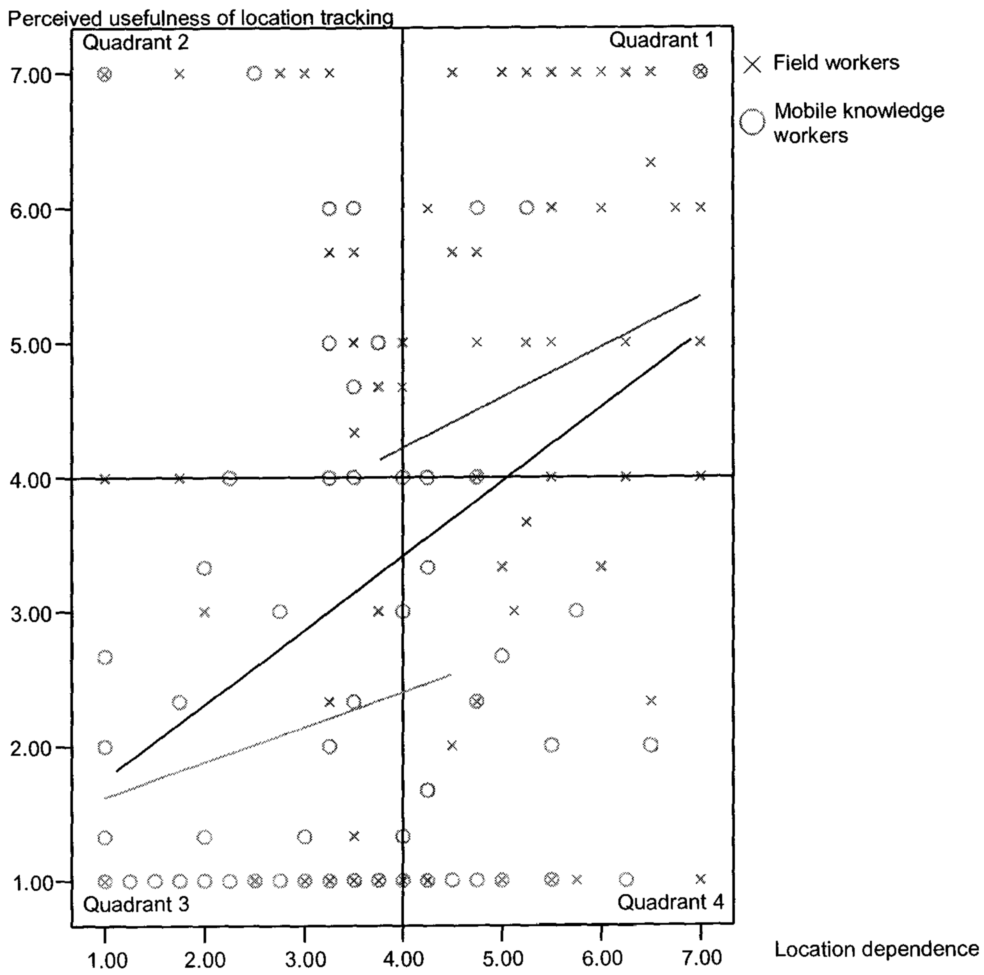


Figure 23: Scatter Plot of Perceived Usefulness of Location Tracking and Location Dependence

Chapter 7: Conclusions

7.1 Answers to Research Questions

(1) How should mobile tasks be modeled?

This study extended the traditional two dimensional task model to a four dimensional model which is better at capturing the features of mobile tasks. The four dimensions are task complexity, task interdependence, time criticality, and location sensitivity. Location sensitivity can be further viewed from two aspects: location variety and location dependence.

(2) How can mobile tasks be evaluated?

Existing instruments are used to measure task complexity and task interdependence. New instruments were developed to measure time criticality and the three aspects of location sensitivity: location variety, location dependence, and location familiarity. The new instruments were validated by empirical data through convergent validation, discriminant validation, and reliability tests.

(3) What are the relationships between dimensions of mobile task characteristics?

According to the analysis conducted through the task model, we found that: Task complexity is negatively correlated with two aspects of location sensitivity (location variety and location dependence). Task interdependence is not correlated with any aspects of location sensitivity and time criticality. Task complexity is positively correlated with task interdependence.

(4) What are the key differences in mobile work between different types of mobile workers?

We found that there are differences in task characteristics between mobile knowledge workers and field workers. Mobile knowledge worker tasks have higher complexity than field worker tasks. Field workers have higher location variety, location dependence, and time criticality than mobile knowledge workers. Mobile knowledge workers have higher task interdependence than field workers.

(5) What are the typical mobile technology functions needed to support mobile work?

Six typical mobile technology functions were identified: mobile communication, including voice communication, text messaging, and mobile notification. In addition, mobile information searching, and mobile transaction processing, including offline transaction processing and online transaction processing. Finally, location related services including location tracking and navigation, and mobile job dispatching which included batch mode job dispatching and real time job dispatching, and mobile office functions.

Discriminant validation tests of the perceived usefulness of these mobile technology functions show that their perceived usefulness of these mobile technology functions are distinct from each other. This, to some degree, demonstrated that the typical mobile functions used in this study are actually different functions, i.e., any two of them are not the same.

(6) How are these perceived usefulness of mobile technology functions related or clustered?

We found that the perceived usefulness of location tracking is highly and positively associated with the perceived usefulness of real time mobile job dispatching. It is also associated with navigation. The perceived usefulness of batch mode mobile job dispatching is positively associated with the perceived usefulness of real time mobile job dispatching. The perceived usefulness of the mobile office is positively associated with the perceived usefulness of mobile information searching. The existence of these associations shows that we may cluster some mobile functions together.

(7) What are the differences between different types of mobile workers in terms of their current usage of, perceived usefulness of, and intention to use mobile technology functions?

The analysis found that there are differences between mobile knowledge workers and field workers in terms of the current usage and the perceived usefulness of typical mobile technology functions. For mobile information searching and the mobile office, mobile knowledge workers use them more and perceived them to be more useful than did field workers. For location related services, mobile offline transaction processing, and mobile job dispatching, field workers used these more and perceived them to be more useful than did mobile knowledge workers. For mobile voice communication, text messaging, and mobile online transaction, the current usage and the perceived usefulness for mobile knowledge workers were the same as for field workers. The pattern of these differences of intention to use is similar to the differences of perceived usefulness.

(8) What is the gap between the current usage of mobile functions and worker intentions to use them?

For field workers, there are no gaps between the current usage of and intention to use mobile voice communication, mobile text messaging, and real time job dispatching. There are gaps for other mobile functions. For mobile knowledge workers, there are gaps for all mobile functions.

The biggest gap for both mobile knowledge workers and field workers is navigation. Mobile knowledge workers prefer more mobile support for all the technology functions they use. But field workers tend to focus more on transaction processing and job dispatching support.

(9) How to define and measure fit?

There are three different definitions of fit: fit as congruence, fit as interaction, and fit as absolute differences. This study used the definition of fit as congruence. For fit as congruence, there are two ways to measure the fit: subjectively and objectively. For subject measurement, there are also two ways to assess the fit: predicted outcomes and facets of fit. This study used predicted outcomes to measure the fit. Specifically, the study use perceived usefulness to measure fit.

(10) What is the ideal fit between the characteristics of mobile tasks and mobile technology functions?

The empirical data collected through the questionnaire were used test the hypotheses. Based on hypothesis tests, the ideal fit is identified Table 59. As shown in the table,

- The perceived usefulness of mobile information searching is positively associated with the task complexity.
- The perceived usefulness of mobile offline transaction processing is negatively associated with task complexity.
- The perceived usefulness of mobile job dispatching (including both batch mode and real time) is negatively associated with task complexity.
- The perceived usefulness of mobile office is positively associated with task complexity.
- The perceived usefulness of mobile notification is positively associated with time criticality.
- The perceived usefulness of location tracking is positively associated with time criticality.
- The perceived usefulness of real time mobile job dispatching is positively associated with time criticality.
- The perceived usefulness of location tracking is positively associated with location variety.

- The perceived usefulness of location tracking is positively associated with location dependence.
- The perceived usefulness of navigation is positively associated with location variety.

Table 59: Ideal Fit Between Task Characteristics and Functionalities of Mobile Technology

		Task Complexity	Task Interdependence	Location Sensitivity: Location Variety	Location Sensitivity: Location Dependence	Time Criticality
1. Mobile communication	Voice					
	Text messaging					
	Notification					Fit: (+) H4-1
2. Mobile information systems searching		Fit: (+) H1-2				
3. Mobile transaction processing	Offline	Fit: (-) H1-3a				
	Online					
7. Location tracking				Fit: (+) H3-1a	Fit: (+) H3-1b	Fit: (+) H4-2
8. Navigation					Fit (+) H3-2	
9. Mobile batch-mode job dispatching		Fit: (-) H1-4a				
10. Mobile real time job dispatching		Fit: (-) H1-4b				Fit: (+) H4-3b
11. Mobile office		Fit: (+) H1-5				

+: The higher the degree of task characteristics, the more perceived usefulness of mobile functions.

-: The lower the degree of task characteristics, the more perceived usefulness of mobile functions.

7.2 Contributions

7.2.1 Theoretical contributions

1) This is the first study to explore the nature of mobile work, based on a theoretical mobile task model. There is lack of theory in the existing literature on mobile work (Perry et al., 2001, Tamminen and Oulasvirta 2004; Wiberg and Ljungberg 1999). Most of previous studies are descriptive. They generally described the behaviour of mobile workers based on observations or work logs, and drew some conclusions. This study establishes a theoretical mobile task model by combining time criticality and location sensitivity with the traditional two task dimensions of complexity and interdependence. Gebauer et al. (2005) extended the traditional task model into three dimensions: task complexity, task interdependence, and time criticality. However, their task model does not include location sensitivity. Junglas and Watson (2003)'s task model focuses on time dependence and location dependence, and their study does include task complexity and task interdependence. The mobile task model used in this study is the most comprehensive mobile task model up to now. With this mobile task model, we have established a theoretical background through which we can examine the nature of mobile work more thoroughly.

2) This study was a systematic and comprehensive study of mobile tasks and workers, which no previous study has ever accomplished. The existing literature has only focused on one type of mobile worker, and usually in one scenario. For example, Perry et al. investigated mobile knowledge workers who are traveling on

business (Perry et al., 2001). Tammine and Oulasvirta (2004) studied the behaviour of mobile people in everyday life. Wiberg and Ljungberg (1999) conducted an ethnographic study of mobile telecommunication engineers. Based on a theoretical mobile task model, this study conducted a systematic investigation of mobile workers. The subjects of this study included both mobile knowledge workers and field workers, including salespersons, managers, mobile professionals, transportation/delivery service workers, field service workers, and emergency service workers. This gives us a broad picture of the nature of mobile work.

3) This study provided some discoveries about the nature of mobile work, based on the empirical data collected. These discoveries are: task interdependence has no relationship with time criticality and location sensitivity; task complexity is positively related with location variety and location dependence; and task complexity and task interdependence are positively related. These discoveries have never been mentioned in previous studies.

4) This was the first study to compare the nature of mobile work between mobile knowledge workers and field workers, finding that the degree of task complexity for mobile knowledge workers is higher than field workers. The degree of task interdependence for mobile knowledge workers is also a little higher than it is for field workers. The degree of time criticality, location variety, and location dependence for mobile knowledge workers was found to be lower than for field workers. Mobile knowledge workers and field workers experience

almost the same degree of location complexity. These findings can help to identify different needs for mobile technology support according to the differing nature of mobile work.

5) This was the first study to develop and validate time and location related constructs through empirical data collected from real world mobile workers. The concepts of time and location have been mentioned and discussed in many studies (Wiberg and Ljungberg 1999; Saugstrup and Henten 2003; Balasubramanian et al., 2002; Junglas and Watson 2003; Gebauer et al. 2005). However, in the previous literature, no instruments were used to measure these constructs. The development of new instruments for time and location related constructs through this study will provide a foundation for future mobile business research.

6) This was the first study to summarize the typical functions that are used to support mobile work. In the existing literature, some studies categorize mobile applications, but the mobile applications they categorize are for general purpose use, and not specifically for mobile work support.

7) This was the first study to examine the current usage of, perceived usefulness of, and intention to use typical mobile technology functions, based on empirical data. And it was the first study to compare related differences in these characteristics for mobile technology functions between mobile knowledge workers and field workers. This study also identified the gap between intention to use and the current usage of mobile technology functions that support mobile work.

8) This study conducted a thorough and comprehensive review and analysis of the concept and measurement of fit, which has been widely used in information systems research, as summarized in Table 5. However, these studies use different views of the concept of fit, and none give a complete picture of the concept. The clarity of the concept of fit established in this work will support future research in information systems.

9) This was the first study to identify the ideal fit between the four dimensions of task characteristics and the six typical mobile work support functions. Gebauer and Shaw (2004) conducted a valuable study in which the ideal fit was explored for a procurement application case. However, the current research covered six typical mobile work support functions and identified the ideal fit, based on the four dimensional task model.

7.2.2 Practical Contributions

1) This study can provide guidance for businesses to strategically plan and deploy mobile workforce support systems, including a guide for selecting a suitable portfolio of mobile applications to fit the needs of a specific business. A company can first assess the nature of their mobile work by examining the task characteristics of their mobile work along four dimensions: task complexity, task interdependence, time criticality, and location sensitivity (which includes location variety, location dependence, and location familiarity). Based on the revealed nature of their mobile work, they will then be able to predict what kind of mobile work technology support is needed.

2) This study can offer mobile technology providers guidance in the development of suitable mobile workforce support systems. If providers know their target markets, they can assess the nature of mobile work in their target markets so that they can determine the kinds of mobile technology functions needed by the target markets. The gap shown in Table 46 and Figures 20 and 21 demonstrate the potential market. If providers already have mobile products, they can check the suitability of their products in particular situations, according to the ideal fit identified in this study.

7.3 Limitations and Future Research

There are some limitations in this study, which could be extended in further research. 1) The contingency variables are not exhaustive and should be extended. In this study the variations explained by independent variables are not large, indicating that some variables may have been missed from the model. Issues such as usability may affect the usefulness of mobile applications, and mobile work usually is more difficult to perform than stationary work. Mobile workers often perform activities other than information processing. Thus, while mobile workers are doing their work, they may experience attention focusing or distraction problems. This issue has been confirmed in many studies. For example, Kristoffersen and Ljungberg's (1999) study found four features of work contexts: a) Tasks external to mobile computer operations are the most important, as opposed to tasks taking place "in the computer". b) Users' hands are often used to manipulate physical objects, as opposed to activities by users in traditional office settings, whose hands are safely and ergonomically placed on the keyboard. c) Users may be involved in tasks ("outside the computer") that demand a high level of visual attention (to avoid danger as well as monitor progress), as opposed to the traditional office setting where a large degree of visual attention is usually directed at the computer. d) Users may be highly mobile during the task, as opposed to in the office, where doing and typing are often separated (Kristoffersen and Ljungberg 1999). The demographics of individual mobile workers such as education level and computer-related skills may also be factors that affect the usefulness of mobile applications. In fact, in the Goodhue and Thomson's (1995) task technology fit model, individual characteristics were included. Incorporating these variables in an expanded research model could produce more comprehensive and sophisticated results.

2) Besides the four dimensions of mobile tasks, there are other dimensions that need to be considered and addressed. For example, whether the task is motivated by task doers themselves or if the task is assigned by others. What kinds of facilities and tools are needed to perform a task and to what degree are they needed? What kind of information is needed for performing a task? Adding more dimensions to the mobile task model will provide a more comprehensive model.

3) This study did not examine the affect of different mobility modalities on the usefulness of mobile work support. Kristoffersen and Ljungberg (2000) have discussed mobile applications for different modality of mobility (wandering, traveling, and visiting). In Chapter 2, we discussed five different mobility

modalities for mobile workers, but we did not include all of them in the research model. This could be a future research topic.

4) This study only gathered empirical data from mobile workers. To examine the usefulness of mobile application, we should not only ask individual worker views, but also manager views from the enterprise perspective. These views may differ in many ways. For example, field workers may prefer paper work to recording work processes and results on mobile devices. But managers may need the data recorded on the mobile devices in order to monitor and check work. Examining this from two different perspectives would give a more comprehensive picture of needs for mobile work support.

5) The investigation of a general task may not capture the whole feature of a task. A task may be further divided into sub-tasks. A mobile worker may perform different types of sub-tasks with quite different characteristics from the main task. For example, it is the main task for a sales person to get a contract. This task can be divided into many sub-tasks, such as: searching and analyzing related information, making appointments with potential customers, preparing presentations, meeting and negotiating with customers, checking inventory, and placing orders. The main task and possibly some of the sub-tasks may not be time critical, but some of the sub-tasks may be very time critical. Also, some of the sub-tasks may be complex tasks, and some may be relatively simple. Taking these factors into consideration may give a better explanation of the empirical results.

6) Since the data were collected in Canada, any generalization of the study's findings to other countries should be done with caution. For example, this study found that text messaging is not popular in mobile work. However, in China, mobile text messaging is very popular, in everyday life and in work situations. If this study were conducted in China, there could be quite different results, due to such environmental differences. Cultural and environmental differences would need to be considered in the explanation of such a study.

References:

Abowd, G. and E. Mynatt (2000). "Charting Past, Present, and Future Research in Ubiquitous Computing." *ACM Transactions on Computer-Human Interaction*, 7(1), 29 - 58.

Ajzen, I. (1985). "From intentions to actions: A theory of planned behaviormmmm." In *Springer series in social psychology*. J. Kuhl and J. Beckmann (Eds.). Berlin: Springer.

Ajzen, I. (1991). *Attitudes, Personality and Behavior*. Milton Keynes: Open University Press,.

Alexander, J. W. and W. A. Randolph (1985). "The fit between technology and structrure as a predictor of performance in nursing subunits." *Academy of Management Journal*, 28, 844-859.

Anderson, J. C., & Gerbing, D. W. (1988). "Structural equation modeling in practice: A review and recommended two-step approach." *Psychological Bulletin*, 103 (3), 411-423.

Aytug, H., M. Lawley, et al. (2005). "Executing production schedules in the face of uncertainties: A review and some future directions." *European Journal of Operational Research*, 161, 86-110.

Babbie, E. (2000). "*The Practice of Social Research.*" Belmont, CA: Wadsworth/Thompson Learning.

Basole, R.C. and R.O. Chao (2004). "Location-Based Mobile Decision Support Systems and User Performance." In *Proceedings of the Tenth Americas Conference on Information Systems*. 2004. New York.

Bagozzi, R. P. (1980). "*Causal models in marketing*." New York: Wiley.

Bagozzi, R. P., Y. Yi and L. W. Phillips (1991). "Assessing construct validity in organizational research." *Administrative Science Quarterly*, 36. 421-458.

Balasubramanian, S., R. A. Peterson, et al. (2002). "Exploring the Implications of M-Commerce for Markets and Marketing." *Journal of the Academy of Marketing Science*, 30(4), 348-361.

Barclay, D., C. Higgins, R. Thompson (1995). "The partial least squares (PLS) approach to causal modeling: Personal computer adoption and use as an illustration." *Tech. Stud.*, 2(2), 285-309.

Barnes, S. (2003). "Enterprise mobility: concept and examples." *International Journal of Mobile Communications*, 1(4), 341-359.

Baumgartner, H., & Homburg, C. (1996). "Applications of structural equation modeling in marketing and consumer research: A review." *International Journal of Research in Marketing*, 13, 139-61.

Bellotti, V. and S. Bly. "Walking away from the desktop computer: distributed collaboration and mobility in a product design team." *Computer Supported Cooperative Work ' 96*. 1996. Cambridge MA USA.

Bentler, P. M., & Chou, C.P. (1987). "Practical issues in structural modeling." *Sociological Methods & Research*, 16, 78-117.

Bergqvist, J., et al. "Moving Out of the Meeting Room - Exploring support for mobile meetings." In *Proceeding of the Sixth European Conference on Computer Supported Cooperative Work ECSCW'99*. 1999. Copenhagen.

Bhattacherjee, A., "Understanding Information Systems Continuance: An Expectation-Confirmation Model." *MIS Quarterly*, 2001. 25(3), 351-370.

Blumberg, D. F. (1994). "Strategies for improving field service operations productivity and quality." *The Service Industries Journal*, 14(2), 262-277.

Bollen, K. A. (1989). *Structural Equations with Latent Variables*. New York: John Wiley and Sons.

Bagozzi, R. P. and L. W. Phillips (1982). "Representing and testing organizational theories: A holistic construal." *Administrative Science Quarterly*, 27, 459-489.

Bagozzi, R.P., Y. Yi and L. W. Phillips, "Assessing construct validity in organizational research." *Administrative Science Quarterly*, 1991. 36, 421-458.

Bentler, P. B. and D. G. Bonett (1980). "Significance tests and goodness-of-fit in the analysis of covariance structures." *Psychological Bulletin*, 88, 588-606.

Boyer, K. K., J. R. Olson, et al. (2002). "Print versus electronic surveys: a comparison of two data collection methodologies." *Journal of Operations Management*, 20, 357-373.

Braverman, H. (1974). *Labor and monopoly capital*. New York, NY: Monthly Review Press.

Brown, B. and M. Chalmers (2003). "Tourism and mobile technology." In *Proceedings of the Eighth European Conference on Computer Supported Cooperative Work.* 2003. Helsinki, Finland: Kluwer Academic Press.

Brown, B. and K. O'Hara (2003). "Place as a practical concern of mobile workers." *Environment and Planning A*, 35(9), 1565 - 1587.

Browne, M.W. and Cudeck, R. (1993). "Alternative Ways of Assessing Model Fit." In Testing Structural Equation Models. K. Bollen and J. S. Long (Eds.). Newbury Park, CA: Sage Publications.

Bruner II, G. C. K., Anand (2003). "Explaining consumer acceptance of handheld Internet devices." *Journal of Business Research.*

Bullock, H. E., L. L. Harlow, et al. (1994). "Causation Issues in Structural Equation Modeling Research." *Structured Equation Modeling*, 1(3), 253-267.

Burns, T. and Stalker, G.M. (1961). *The Management of Innovation.* London, Heinemann.

Bystrom, K. (1999). *Task complexity, information types and information sources - Examination of relationship.* Department of Information Studies. Finland, University of Tampere, Doctoral dissertation.

Bystrom, K. and K. Jarvelin (1995). "Task complexity affects information seeking and use." *Information Processing & Management*, 31, 191-213.

Campbell, D. T. and D. W. Fiske (1959). "Convergent and discriminant validation by the multitrait-multimethod matrix." *Psychological Bulletin*, 56, 81-105.

Campell, D. J. (1988). "Task Complexity: A Review and Analysis." *The Academy of Management Review*, 13(1), 40-52.

Campion, M. A., G. J. Medsker, et al. (1993). "Relations between work group characteristics and effectiveness: Implications for designing effective work groups." *Personnel Psychology*, 46, 821-850.

Carini, R. M., J. C. Hayek, et al. (2003). "College Student Responses to Web and Paper Surveys: Does Mode Matter?" *Research in Higher Education*, 44(1), 1-19.

Carlstein, T. (1982). "Time resources, society, and ecology." Boston, Allen & Unwin.

Carmines, E. G. and R. A. Zeller (1979). *Reliability and validity assessment*. Sage, CA: Beverly Hills.

Chen, G. and K. Kotz (2000). *A Survey of Context-Aware Mobile Computing Research*. Darthmouth: Department of Computer Science, Dartmouth College, Technical Report.

Chen, L.-d. and R. Nath (2004). "A framework for mobile business applications." *International Journal of Mobile Communications*, 2(4), 368 - 381.

Choudhury, V. and J. L. Sampler (1997). "Information Specificity and Environmental Scanning: An Economic Perspective." *MIS Quarterly*, 21(1), 25-53.

Clarke, I. (2001). "Emerging value propositions for m-commerce." *Journal of Business Strategies*, 18(2), 133-148.

Compeau, D. R. and C. A. Higgins (1995). "Computer Self-Efficacy: Development of a Measure and Initial Test." *MIS Quarterly*, 19(2), 189-211.

Conte, S. D., H. E. Dunsmore, et al. (1986). *Software Engineering Metrics and Models*. Menlo Park CA: Benjamin/Cummings.

Cook, T. D. and D. T. Campbell (1979). *Quasi Experimentation: Design and Analytical Issues for Field Settings*. Chicago: Rand McNally.

Cronbach, L. J. (1971). "Test Validation." In *Educational Measurement*. R. L. Thorndike (Eds.). Washington DC: American Council on Education.

Curley, K. and P. Pyburn (1982). ""Intellectual" technologies: the key to improving white-collar productivity." *Sloan Management Review*, 24(1), 31-40.

Daft, R. L. and R. H. Lengel (1984). "Information Richness: A New Apporach to Manager Information Processing and Organization Design." In *Research in Organizational Behavior*. B. Staw and L. L. Cummings (Eds.). Greenwich, Conn.: JAI Press.

Daft, R. L. and R. H. Lengel (1986). "Organizational Information Requirements, Media Richness and Structural Design." *Management Science*, 32(5), Organization Design), 554-571.

Daft, R. L. and N. B. Macintosh (1981). "A Tentative Exploration into the Amount and Equivocality of Information Processing in Organizational Work Units." *Administrative Science Quarterly*, 26(2), 207-224.

Davern, M. J. (1996). "When Good Fit is Bad: The Dynamics of Perceived Fit." *The Seventeenth International Conference on Information Systems*, Cleveland, Ohio.

David, F. R., P. J.A., et al. (1989). "Linking technology and structure to enhance group performance." *Journal of Applied Psychology*, 74(2), 233-241.

Davis, F. (1989). "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology." *MIS Quarterly*, 13(3), 319-339.

Dey, A. K. (2001). "Understanding and Using Context." *Personal and Ubiquitous Computing Journal*, 5(1), 4-7.

Dey, A. K. and G. D. Abowd (2000). "Towards a better understanding of context and context-awareness." In *Workshop on The What, Who, Where, When, and How of Context-Awareness, Conference on Human Factors in Computer Systems (CHI2000).*

De Vaus, D. (1991). "Surveys in Social Research." Sydney: Allen and Unwin.

Dill, W. R. (1958). "Environment as an influence on managerial autonomy." *Administrative Science Quarterly*, 2, 409-443.

Dishaw, M. T. and D. M. Strong (1998). "Assessing Software Maintenance Tool Utilization using Task-technology Fit and Fitness-for-use Models." *Software Maintenance: Research and Practice*, 10, 151-179.

Dishaw, M. T. and D. M. Strong (1999). "Extending the technology acceptance model with task-technology fit constructs." *Information & Management*, 36, 9-21.

Dix, A., T. Rodden, et al. (2000). "Exploiting Space and Location as a Design Framework for Interactive Mobile Systems." *ACM Transactions on Computer-Human Interaction*, 7(3), 285-321.

Dix, A. J. and R. Beale (1996). *Remote Cooperation: CSCW Issues for Mobile and Teleworkers*. New York: Springer.

Doll, W. J. and G. Torkzadeh (1998). "Developing a multidimensional measure of system-use in an organizaitonal context." *Information Management*, 33, 171-185.

Donaldson, L. (1995). *American Anti-Managment Theories of Organization: A Critique of Paradigm Proliferation.* Cambridge UK: Cambridge University Press.

Donaldson, L. (1996). *For Positivist Organization Theory: Proving the Hard Core*. London: Sage.

Donaldson, L. (2001). *The Contingency Theory of Organisations.* CA: Sage, Thousand Oaks.

Downey, H. K. and J. W. Slocum (1975). "Uncertainty: Measures, Research, and Sources of Variation." *The Academy of Management Journal*, 18(3), 562-378.

Drazin, R. and A. H. V. d. Ven (1985). "Alternative Forms of Fit in Contingency Theory." *Administrative Science Quarterly*, 30(4), 514-539.

Egelhoff, W. G. (1991). "Information-Processing Theory and the Multinational Enterprise." *Journal of International Business Studies*, 22(3), 341-368.

Emery, F. L. and E. L. Trist (1969). "Socio-technical systems." In *Systems Thinking*. F. L. Emery (Eds.). London: Penguin.

Fang, X. C., Susy; Brzezinski, Jacek; Xu, Shuang (2003). "A Study of Task Characteristics and User Intention to Use Handheld Devices for Mobile Commerce." In *Proceedings of the Second Annual Workshop on HCI Reseach in MIS*, Seattle, WA.

Fishbein, M. and I. Ajzen (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research.* MA.: Addison-Wesley, Reading.

Fornell, C. and D. Larcker (1981), "Evaluating structural equation models with unobservable variables and measurement error." *Journal of Marketing Research*, 18(3), 39-50.

Fry, L. W. and J. W. Slocum (1984). "Technology, Structure, and Workgroup Effectiveness: A Test of a Contingency Model." *The Academy of Management Journal*, 27(2), 221-246.

Galbraith, J. (1973). *Designing Comples Organizations*. MA: Addison-Wesley Reading.

Garner, W. (1962). *Uncertainty and structure as psychological concepts*. New York: Wiley.

Garrity, E. J. and G. L. Sanders (1998). "Dimensions of Information Systems Success." In *Information Systems Success Measurment*. E. J. Garrity and G. L. Sanders (Eds.). Hershey, USA; London, UK: Idea Group Publishing.

Garson, G. D. (2001). "Factor analysis."

http://www2.chass.ncsu.edu/garson/pa765/factor.htm (28 Feb. 2007)

Gartner (2002). "Trends and Developments in Wireless Data Applications." http://www.siventures.com/portfolio/pdf/070202/Wireless%20Data%20Applications.pdf (27 Feb. 2007).

Gebauer, J. and M. Shaw (2004). "Success factors and impacts of mobile business applications: Results from a mobile e-procurement study." *International Journal of Electronic Commerce*, 8(3), 19-41.

Gebauer, J., M. J. Shaw, Michele L. Gribbins (2005). "Towards a Specific Theory of Task-Technology Fit for Mobile Information Systems." College of Business, University of Illinois at Urbana-Champaign, Working paper.

Gefen, D. (2002). "Reflections on the dimensions of trust and trustworthiness among online consumers." *The DATA BASE for Advances in Information Systems*, 33(3), 38-53.

Gefen, D., E. Karahanna, et al. (2003). "Trust and TAM in online shopping: an integrated model." *MIS Quarterly*, 27(1), 51-90.

Gefen, D., D. W. Straub, et al. (2000). "Structural Equation Modeling and Regression: Guidelines for Research Practice." *Communications of the Association for Information Systems* 4(7), 1-70.

Giddens, A. (1984). *The Constitution of Society: Outline of the Theory of Structure*. Berkeley, CA: University of California Press.

Giddens, A. (1990). *The consequences of modernity*. Cambridge, UK: Polity Press.

Good, D. J. and R. J. Schultz (2000). *Strategic, Organizational, and Managerial Impacts of Business Technologies*. London: Quorum Books.

Goodhue, D. L. (1995). "Understanding User Evaluations of Information Systems." *Management Science*, 41(12), 1827-1844.

Goodhue, D. L. (1998). "Development and Measurement Validity of a Task-Technology Fit Instrument for User Evaluations of Information Systems." *Decision Sciences*, 29(1), 105-139.

Goodhue, D. L. and R. L. Thompson (1995). "Task-Technology Fit and Individual Performance." *MIS Quarterly*, 19(2), 213-236.

Gorry, G. A. and M. S. Scott Morton (1971). "A Framework for Management Information Systems." *Sloan Management Review*, 13(1), 55-70.

Gory, G. A. and S. Morton (1971). "A framework for managment information systems." *Sloan Management Review*, 13(1), 55-70.

Gray, P. and D. Salber (1997). "Modelling Space for Location-Dependent Tasks: Why Location-Independent Computing Isn't." *CHI'97 workshop on "Ubiquitous Computing: The Impact on Future Interaction Paradigms and HCI Research"*, Atlanta .March, 1997.

Hackathorn, R. D. and P. G. W. Keen (1981). "Organizational Strategies for Computing in Decision Support Systems." *MIS Quarterly*, 5(3), 21-26.

Hackman, J. R. (1968). "Effects of task characteristics on group products." *Journal of Experimental Social Psychology*, 4, 162-187.

Hackman, J. R. and N. Vidmar (1970). "Effects of size and task type on group performance and member reactions." *Sociometry*, 33, 37-54.

Hage, J. and M. Aiken (1969). "Routing technology, social structure and organizational goals." *Administrative Science Quarterly*, 14, 368-379.

Hagerstrand, T. (1975). "Space, Time and Human Conditions." In *Dynamic Allocation of Urban Space.* Karlqvist, A. , Lundqvist, L., and Snickars, F. (Eds.). Westmead: Saxon House.

Hair, J. F., R. E. Anderson, et al. (1998). *Multivariate Data Analysis with Readings*. Englewood Cliffs, NJ: Prentice Hall.

Hassard, J. (1996). "Images of time in work and organizations." In *Handbook of organization studies*. Clegg, S. R., Hardy, C. and Nord, W. R. (Eds.). Sage, CA: Thousand Oaks.

Hayes, K. and S. Kuchinskas (2003). *Going mobile building the real-time enterprise with mobile applications that work.* San Francisco: CMP Books.

Hickson, D. J., D. S. Pugh, et al. (1969). "Operations technology and organization structure: an empirical reappraisal." *Administrative Science Quarterly*, 14, 378-397.

Higgins C., L. Duxbury, R. Irving (1992). "Work-family conflict in the dual-career family." *Organ. Behavior and Human Decision Process*, 51(1), 51-75.

Hirschhorn, L. (1981). "The post-industrial labor process." *New Political Science*, 11-32.

Hirschhorn, L. and K. Farduhar (1985). "Productivity, technology and the decline of the autonous professional." *Office Technol People*, 2, 245-265.

Hu, L. and P. M. Bentler (1999). "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives." *Structural Equation Model*ing, 6, 1-55.

Hulland, J.S. (1999). "Use of partial least squares (PLS) in strategic management research: A review of four recent studies." *Strategic Management Journal*, 20, 195–204.

Hung, S. Y., Ku, C.Y., and Chang C.M. (2003). "Critical factors of WAP services adoption: an empirical study." *Electronic Commerce Research and Applications*, 2(1), 42-60.

Hunt, S. D. (1983). *Marketing Theory: The Philosophy of Marketing Science*. Homewood, IL: Richard D. Irwin.

Ingram, T.N. (1990). "Improving Sales Force Productivity: A Critical Examination of the Personal Selling Process." *Review of Business*, 1(12), 7-11.

Jarvenpaa, S. L., N. Tractinsky, et al. (2000). "Consumer Trust in an Internet Store." *Information Technology and Management*, 1(1-2), 45-71.

Jobber, D., J. Saunders, and V.-W. Mitchell (2002), "Prepaid monetary incentive effects on mail survey response." *Journal of Business Research*.

Junglas, I. A. (2003). *U-Commerce: An Experimental Investigation of Ubiquity and Uniqueness*. Terry College of Business, University of Georgia, Doctoral Dissertation.

Junglas, I. A. and R. T. Watson (2003). "U-Commerce: A Conceptual Extension of E- and M-Commerce." *International Conference on Information Systems 2003*, Seattle, WA.

Keller, R. T. (1994). "Technology-Information Processing Fit and the Performance of R&D Project Groups: A Test of Contingency Theory." *The Academy of Management Journal*, 37(1), 167-179.

Kidder, L. H. and C. M. Judd (1986). *Research Methods in Social Relation*. New York NY: Holt Rinehart and Winston.

Kirs, P. J., G. L. Sanders, et al. (1989). "An experimental validation of the Gorry and Scott Morton Framework." *MIS Quarterly*, 13(2), 183-197.

Kleinrock, L. (1995). "Nomadic Computing - An Opportunity." *Computer Communication Review*, 25(1,), 36-40.

Kleinrock, L. (1996). "Nomadicity: Anytime, Anywhere in a Disconnected World." *Mobile Networks and Applications*, 1(4), 351-357.

Kline, R. B. (1991). "Latent variable path analysis in clinical research: A beginner's tour guide." *Journal of Clinical Psychology*. 47, 471-484.

Kraemer, K. and J. Danziger (1990). "The impacts of computer technology on the worklife of information workers." *Social Science Computer Review*, 8(4), 592-613.

Kristoffersen, S. and F. Ljungberg (2000). "Mobility: From stationary to mobile work." in *Planet Internet*. K. Braa, C. Sorensen, B. Dahlbom (Eds.), Lund, Sweden: Studentlitteratur.

Lai, V. (1999). "A contingency examination of CASE-task fit on software developer's performance." *European Journal of Information Systems*, 8, 27-39.

Lakoff, G. and M. Johnson (1980). *Metaphors We Live By*. Chicago: University of Chicago Press.

Lawrence, P. R. (1993). "The Contingency Approach to Organizational Design." In *Handbook of Organizational Behavior*, Robert T. Golembiewski (Eds.). New York: Marcel Dekker.

Lawrence, P. R. and J. W. Lorsch (1967). *Organization and Environment: Managing Differentiation and Integration*. Boston, Harvard University, Graduate School of Business Admininstration, Division of Research.

Lee, H. and J. Liebenau (1999). "Time in organisational studies: Towards a new research direction." *Organisation Studies*, 20(6), 1035-1058.

Lee, H. and J. Liebenau (2000). "Temporal effects of information systems on business processes: focusing on the dimensions of temporality." *Accounting, Management and Information Technologies*, 10(3), 157-185.

Lee, K. C., S. Lee, et al. (2004). "Analysis of Mobile Commerce Performance by using the Task-Technology Fit." *Mobile Information Systems, IFIP TC 8*

Working Conference on Mobile Information Systems (MOBIS), Oslo, Norway.

Lee, W. J. K., Tae Ung; Chung, Jay-Young (2002). "User Acceptance of the mobile Internet." IT Management Research Center, Graduate School of Business, Sungkyunkwan University, Seoul, Korea. http://citeseer.ist.psu.edu/cache/papers/cs/26605/http:zSzzSzwww.mobiforum.orgzSzproceedingszSzpaperszSz09zSz9.3.pdf/user-acceptance-of-the.pdf (27 Feb. 2007).

Liang, T.-P. and C.-P. Wei (2004). "Introduction to the Special Issue: Mobile Commerce Applications." *International Journal of Electronic Commerce*, 8(3), 7-17.

Liff, S. (1990). "Clerical workers and information technology: gender relations and occupational change." *N Technol Work Employment*, 18, 4-28.

Lilischkis, S. (2003). *More Yo-yos, Pendulums and Nomads:Trends of Mobile and Multi-location Work in the Information Society*. Issue Report N. 36.

Litwak, E. (1961). "Models of Bureaucracy Which Permit Confict." *American Journal of Sociology*, 67, 177-184.

Long, J. S. (1983). *Confirmatory Factor Analysis*. Sage, CA: Beverly Hills,.

Luff, P. and C. Heath (1998). "Mobility in Collaboration." *CSCW 98*, Satde Washinson USA.

Lyytinen, K. and Y. Yoo (2002). "Research Commentary: The Next Wave of Nomadic Computing." *Information Systems Research*, 13(4), 377-388.

Malone, T. W. and K. Crowston (1994). "The interdisciplinary study of coordination." *Computing Surveys*, 26(1), 87-119.

Marcoulides, G. A. (1998.). *Modern methods for business research*. Mahwah, N.J.: Lawrence Erlbaum.

Marsh, H. W. and D. Hovecar (1985). "Application of confirmatory factor analysis to the study of self-concept: first and higher order factor models and their invariance across groups." *Psychological Bulletin*, 97(3), 562-582.

Mennecke, B. E. and T. Strader (2001). "Where in the World the Web Does Location Matter? A Framework for Location Based Services in mCommerce." In the *Proceedings of the Seventh Americas Conference on Information Systems*, Boston, Massachusetts.

Miller, G. A. and F. C. Frick (1949). "Statistical behaviorists and sequences of responses." *Psychological Review*, 56, 623-648.

Mirani, R. and A. L. Lederer (1998). "An instrument for assessing the organizational benefits of IS projects." *Decision Sciences*, 29(4), 803-838.

Moore, W. (1963). *Man, time and society*. New York: Wiley.

Musil, C. M., S. L. Jones, et al. (1998). "Structural Equation Modeling and Its Relationship to Multiple Regression and Factor Analysis." *Research in Nursing & Health*, 21, 271-281.

Nance, W. D. and D. W. Straub (1996). "An Investigation of Task/Technology Fit and Information Technology Choices in Knowledge Work." *Journal of Information Technology Management*, 7(3/4), 1-14.

Nah, F.F.-H., K. Siau, and H. Sheng (2005), "The value of mobile applications; a utility company study." *Communications of the ACM*, 48(2).

Nidumolu, S. R. (1996). "A Comparison of the Structural Contingency and Risk-based Perspectives on Coordination in Software development Projects." *Journal of Management Information Systems*, 13(2), 77-113.

Nilsson, M. and M. Hertzum (2005). "Negotiated Rhythms of Mobile Work: Time, Place, and Work Schedules." In *Proceedings of the 2005 International ACM SIGGROUP Conference on Supporting Group Work (GROUP 2005),* Sanibel Island, FL.

Nunnally, J.C. (1978). *Psychometric Theory.* New York: McGraw Hill.

Nunnally, J. C. and R. L. Durham (1975). "Validity, reliability, and special problems of measurement in evaluation research." In *Handbook of evaluation research*. E. L. Struening and M. Guttentag (Eds.). Sage,CA: Beverly Hills.

Ohta, H. (1993). "Introduction: In Honour of Melvin L. Greenhut." in *Does Economic Space Matter: Essays in Honour of Melvin L. Greenhut*. Hiroshi Ohta and Jacques-François Thisse (Eds.). New York: St. Martin's.

Pearce, J. L., S. M. Sommer, et al. (1992). "A Configurational Approach to Interpersonal Relations: Profiles of Workplace Social Relations and Task Interdependence." Working paper GSM #OB92015, University of California, Irvine.

Pedersen, P. E. (2002). "Adoption of mobile Internet services: An exploratory study of mobile commerce early adopters." Agder University College. http://ikt.hia.no/perep/earlyadopt_paper.pdf (27 Feb. 2007).

Pedhazur, E. J. (1997). *Multiple Regression in Behavioral Research*. New York: Harcourt Brace.

Pennings, J. M. (1987). "Structrual Contingency Theory: A Multivariate Test." *Organization Studies*, 8: 223-240.

Pennings, J. M. (1992). "Structural Contingency Theory: A Reappraisal." *Research in Organizational Behavior*, 14, 267-309.

Perrow, C. (1967). "A Framework for the Comparative Analysis of Organization." *American Sociological Review*, 32(2), 194-208.

Perry, M., K. O'Hara, et al. (2001). "Dealing with Mobility: Understanding Access Anytime, Anywhere." *ACM Transactions on Computer-Human Interaction*, 8(4), 323-347.

Perry, M., K. O'hara, et al. (2001). "Dealing with Mobility: Understanding Access Anytime, Anywhere." *ACM Transactions on Computer-Human Interaction*, 8(4), 323-347.

Pfeffer, J. (1982). *Organizations and Organization Theory*. Marshfield, MA: Pitman.

Poole, M. S. (1978). "An Information-Task Approach to Organizational Communication." *The Academy of Management Review*, 3(3), 493-504.

Puuronen, S. and V. Savolainen (1997), "Mobile information systems - executives' view." *Info System J.*, 7, 3-20.

Reinfeld, N. V. (1959). *Production Control.* Englewood Cliffs, NJ: Prentice-Hall.

Sampler, J. L. (1998). "Redefining Industry Structure for the Information Age." *Strategic Management Journal*, 19, 343-355.

Saugstrup, D. and A. Henten (2003). "Mobile service and application development in a mobility perspective." In *Proceedings of the 8th International Workshop on Mobile Multimedia Communications, Opening Up New Frontiers in Mobile Business and Technology.*

Schilit, B., N. Adams, et al. (1994). "Context-Aware Computing Applications." *IEEE Workshop on Mobile Computing Systems and Applications.*

Schmidt, A., K. A. Adoo, et al. (1999). "Advanced Interaction in Context." *Lecture Notes in Computer Science.*

Schoonhoven, C. B. (1981). "Problems with Contingency Theory: Testing Assumptions Hidden within the Language of Contingency "Theory"." *Administrative Science Quarterly*, 26(3), 349-377.

Schriber, J. B. (1986). *An exploratory study of the temporal dimensions of work organizations.* The Claremont Graduate School, Doctoral dissertation.

Schriber, J. B. and B. A. Gutek (1987). "Some time dimensions of work: the measurement of an underlying aspect of organization culture." *Journal of Applied Psychology*, 72, 642-650.

Seddon, P. B. and R. Scheepers (2006). "Other-settings Generalization in IS Research." *International Conference in Information Systems(2006)*, Milwaukee, Wisconsin.

Shaiken, H. (1985). *Work transformed: automation and labor in the computer age.* New York: Holt, Rinehart and Winston.

Shannon, C. and W. Weaver (1949). *The Mathematical Theory of Communication.* Urbana: University of Illinois Press.

Sharma, R. and P. Yetton (2003). "The Contingent Effects of Management Support and Task Interdependence on Successful Information Systems Implementation." *MIS Quarterly*, 27(4).

Smith, N. and C. Katz (1993). "Grounding Metaphor: Towards a Spatialised Politics." in *Place and the Politics of Identity.* M Keith and S Pile (Eds.). London: Routledge.

Staples, D. S. and P. Seddon (2004). "Testing the Technology-to-Performance Chain Model." *Journal of Organizational and End User Computing*, 16(4), 17-36.

Stelzl, I. (1986). "Changing a Causal Hypothesis without Changing the Fit: Some Rules for Generating Equivalent Path Model." *Multivariate Behavioral Research*, 21, 309-331.

Straus, S. G. and J. E. McGrath (1994). "Does the medium matter? The interaction of task type and technology on group performance and member reactions." *Journal of Applied Psychology*, 79(1), 87-97.

Sulek, J. and A. Marucheck (1992). "A study of the impact of an integrated information technology on the time utilization of information workers." *Decision Sciences*, 23, 1174-1191.

Tamminen, S., A. and e. a. Oulasvirta (2004). "Understanding mobile contexts." *Personal and Ubiquitous Computing*, 8(2), 135 - 143.

Tamminen, S., A. Oulasvirta, et al. (2004). "Understanding mobile contexts." *Personal and Ubiquitous Computing*, 8(2), 135 - 143.

Tanis, J. and F. Duffy (1999). "A Vision of the New Workplace Revisited." *Site Selection*, September.

Taylor, S. and P. A. Todd (1995). "Understanding Information Technology Usage: A Test of Competing Models." *Information Systems Research*, 6(2), 144-176.

Thompson, J. (1967). *Organizational action.* New York: McGraw Hill.

Tiamiyu, M. (1992). "The relation between source use and work complexity, decision making discretion and activity duration in Nigerian government ministries." *International Journal of Information Management*, 12, 130-141.

Tomarken, A. J. and N. G.Waller (2005). "Structural Equation Modeling: Strengths, Limitations, and Misconceptions." *Annu. Rev. Clin. Psychol.,* 1, 31-35.

Torkzadeh, G. and W. J. Doll (1999). "The development of a tool for measuring the perceived impact of information technology on work." *Omega*, 27, 327-339.

Turner, J. (1985). "Organizational performance, size, and the use of data processing resources." Working paper 58, Center for Research in Information Systems, New York University, New York.

Tushman, M. L. (1978). "Technical Communication in R & D Laboratories: The Impact of Project Work Characteristics." *The Academy of Management Journal*, 21(4), 624-645.

Tushman, M. L. (1979). "Work characteristics and subunit communication structure: A contingency analysis." *Administrative Science Quarterly*, 24(1), 82-98.

Tushman, M. L. and D. A. Nadler (1978). "Information Processing as an Integrating Concept in Organization Design." *Academy Management Review*, 3, 613-624.

Urry, J. (2000). "Mobile sociology." *British Journal of Sociology*, 51(1), 185-203.

Urry, J. (2000). *Sociology Beyond Societies*. London: Routledge.

Vakkari, P. (1998). "Growth of theories on information seeking: An analysis of growth of a theoretical research program on the relation between task complexity and information seeking." *Information Processing & Management*, 34(2/3), 361-382.

Vakkari, P. (2003). "Task-based information searching." *Annual Review of Information Science and Technology*, 37, 413-464.

Valavanis, S. (1955). "Losch on Location." *American Economic Review*, 45, 637-644.

Van de Ven, A. and D. Ferry (1980). *Measuring and assessing organizations.* New York, NY: Wiley.

Van de Ven, A. H. and A. L. Delbecq (1974). "A Task Contingent Model of Work-Unit Structure." *Administrative Science Quarterly*, 19(2), 183-197.

Van de Ven, A. H., D. Delbecq, et al. (1976). "Determinants of coordination modes within organizations." *American Sociological Review*, 41(2), 322-338.

Van de Ven, A. H. and R. Drazin (1985). "The concept of fit in contingency theory." In *Research in Organizational Behavior.* L.L. Cummings and B.M. Staw (Eds).

Varshney, U. and R. Vetter (2002). "Mobile Commerce: Framework, Application and Networking Support." *Mobile Networks and Applications*, 7(3), 185-198.

Venkatesh, V. and F. D. Davis (2000). "A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies." *Management Science*, 46(2), 186-204.

Venkatesh, V., M. G. Morris, et al. (2003). "User Acceptance of Information Technology: Toward a unified view." *MIS Quarterly*, 27(3), 425-478.

Venkatraman, N. (1989). "The Concept of Fit in Strategy Research: Toward Verbal and Statistical Correspondence." *The Academy of Management Review*, 14(3), 423-444.

Wakefield, R. and Whitten, D. (2006) "Mobile computing: a user study on hedonic/utilitarian mobile device usage." *European Journal of Information Systems*, 15, 292–300.

Watson, R. T., L. F. Pitt, et al. (2002). "U-Commerce: Expanding the Universe of Marketing." *Journal of the Academy of Marketing Science*, 30(4), 333 -- 347.

Weick, K. (1979). *The Social Psychology of Organizing*. Mass: Addison-Wesley Reading.

Weick, K. (1990). "Technology as equivoque: sensemaking in new technologies." In *Technology and organization, Goodman PS.* Sproull LS et al. (Eds). San Francisco: Jossey-Bass.

Weil, P. (1992). "The Relationship between Investment in Information Technology and Firm Performance: A Study of the Valve Manufacturing Sector." *Information Systems Research*, 3(4), 307-333.

Whipp, R., B. Adam, et al. (2002). *Making Time. Time and Management in Modern Organizations*. Oxford ; New York : Oxford University Press.

Whittaker, S., D. Frohlich, et al. (1994). "Informal workplace communication: What is it like and how might we support it?" In *Proceedings '94 Conference on Human Factors In Computing Systems*, New York.

Wiberg, M. and F. Ljungberg (1999). "Exploring the vision of 'anytime, anywhere' in the context of mobile work." In *Knowledge Management and Virtual Organizations*. Y. Malhotra (Eds.). Idea Group Publishing.

Withey, M., R. L. Daft, et al. (1983). "Measures of Perrow's Work Unit Technology: An Empirical Assessment and a New Scale." *The Academy of Management Journal*, 26(1), 45-63.

Woodward, J. (1965). *Industrial Organization: Theory and Practice*. Oxford, UK: Oxford Unversity Press.

Wu, J. and Wang, S.(2005). "What drives mobile commerce? An empirical evaluation of the revised technology acceptance model." *Information & Management,* 42, 719–729.

Yarbrough, M. (2001). "Applications for the mobile sales force." http://www.palmpowerenterprise.com/issues/issue200102/sales0201001.htm l (27 Feb. 2007)

Younger, J. (1930). *Work Routing in Production Including Scheduling and Dispatching*. New York: Ronald.

Yuan, Y. and W. Zheng (2005). "From Stationary Work Support to Mobile Work Support: A Theoretical Framework." *International Conference on Mobile Business (ICMB'05)*, Sydney, Australia.

Yuan, Y. and W. Zheng (2006). "The Fit between Mobile Task and Mobile Work Support: A Theoretical Framework." *International Conference on Mobile Business (ICMB'06)*, Copenhagen, Denmark.

Zeffane, R. M. and F. Gul (1993). "The effects of task characteristics and sub-unit structure on dimensions of information processing." *Information Processing and Management*, 29(6), 703-719.

Zerubavel, E. (1981). *Hidden rhythms: schedules and calendars in social life.* Chicago: University of Chicago Press.

Zheng, W. and Y. Yuan (2007). "Identifying the differences between stationary office support and mobile work support: a conceptual framework." *International Journal of Mobile Communications*, 5(1), 107 - 122.

Zigurs, I. and B. K. Buckland (1998). "A Theory of Task/Technology Fit and Group Support Systems effectiveness." *MIS Quarterly*, 22(3), 313-334.

Zigurs, I., B. K. Buckland, et al. (1999). "A test of task-technology fit theory for group support systems." *Database for Advances in Information Systems*, 30(3/4), 34-50.

Zmud, R. W. (1983). *Information Systems in Organizations*. Palo Alto, CA: Scott, Foresman and Company.

Zuboff, S. (1988). *In the age of the smart machine: the future of work and power.* New York, NY: Basic Books.

Appendix A: Glossary

APs - Access Points

AVE – Average Variance Extract

CFA - Confirmatory Factor Analysis

CR – Composite Reliability

CRM – Customer Relationship Management

DSL - Digital Subscriber Link

ERP – Enterprise Resource Planning

GFI - Goodness-of-Fit Index

GPRS General Packet Radio Service

GPS - Global Positioning System

GSM - Global System for Mobile

GSS - Group Support System

IrDA - Infrared

IS – Information System

IT – Information Technology

LAN – Local Area Networks

LBS – Location Based Service

M-DSS - Mobile Decision Support Systems

MFW – Mobile Field Workers

MKW – Mobile Knowledge Workers

MLS - Multiple Listing Service

MMS - Multi Media Messaging

MWS – Mobile Work Support

MTMM - MultiTrait-MultiMethod

PCA - Principal Components Analysis

PDA – Personal Digital Assistant

PLS – Partial Least Square

PMR - Private Mobile Radio Networks

PSTN - Public Switched Telephone Network

RFID - Radio Frequency Identification

SEM - Structural Equation Modeling

SMS - Short Message Service

TRA - Theory of Reasoned Action

TAM – Technology Acceptance Model

TPB - Theory of Planned Behavior

TTF – Task Technology Fit

U-Commerce: Ubiquity, Universality, Uniqueness and Unity

UMTS - Universal Mobile Telecommunication System

UTAUT - Theory of Acceptance and Use of Technology

WAP – Wireless Access Protocol

WLAN - Wireless Local Area Networks

WPAN - Wireless Personal Area Networks

WWAN - Wireless Wide Area Networks

Appendix B: Consent Letter and Questionnaire

Research Study
Investigation of Mobile Work Support

MeRC (McMaster eBusiness Research Centre),
DeGroote School of Business,
McMaster University

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Purpose of the Study

The objective of the research is to understand the value of mobile work support for different kinds of mobile tasks and mobile technologies.

Procedures involved in the Research

You are invited to fill out the following questionnaire on the nature of your mobile work and your needs for mobile technology. It will take about 15 minutes.

Potential Harms, Risks or Discomforts:

It is not likely that there will be any harms or discomforts associated with filling out the questionnaire.

You do not need to answer questions that make you uncomfortable or that you do not want to answer.

Payment or Reimbursement:

To show our appreciation, you will receive a 10-dollar Tim Hortons gift certificate. Please tell us your mail address by email (zhengw3@mcmaster.ca) or by fax (905 521 8995) (please fax your mail address on a separate sheet, i.e, not in the sheets of the questionnaire). If you mail the completed questionnaire to us, please put your mail address on the envelope. We will keep this information that identifies you separate from your answers.

Confidentiality

Your privacy will be respected. All information we collect from this survey will be kept in strict confidence. We are not interested in individual results, only in the aggregate data the survey produces. None of your individual response will be told to anyone else. You will not be identified individually in any reports or analyses resulting from this research project.

After the study is finished all raw data will be deleted or shreded.

Participation:

Your participation in this study is voluntary. It is your choice to be part of the study or not. If you decide to participate, you can decide to stop at any time. If you decide to stop participating, there will be no consequences to you.

Information about the Study Results:

If you would like to know the results of the study, there will be information available at the following website: http://merc.mcmaster.ca

Information about Participating as a Study Subject:

If you have questions or require more information about the study itself, please contact Dr. Yufei Yuan at yuanyuf@mcmaste.ca or 905 525 9140 - 23982.

This study has been reviewed and approved by the McMaster Research Ethics Board. If you have concerns or questions about your rights as a participant or about the way the study is conducted, you may contact: McMaster Research Ethics Board Secretariat, telephone: (905) 525-9140 ext. 23142, c/o Office of Research Services, E-mail: ethicsoffice@mcmaster.ca.

Reading this consent letter and then filling out the questionnaire, implies that you understand the terms outlined above and consent to our using your data as part of this research project.

Thank you very much for your time and support!

Please think of **a typical mobile work situation,** in which mobile technology helps you or may help you to perform your task. Answer the following questions according to this situation.

1. Please select the percentage of your **work time** when you:

	0% - 20%	20%- 40%	40%- 60%	60%- 80%	80%- 100%
1.1 Work **outside of your fixed office desk**					
1.2 Work **around local areas** (such as in a building)					
1.3 Work in **regional areas** (such as in a city)					
1.4 Work **outside of your city or country**					

2. To what extent do you agree with the following statements on the degree of **task complexity**?

1- Strongly disagree; 4-Neutral; 7-Strongly agree

2.1 Your work **is repetitive**	1 2 3 4 5 6 7
2.2 Your work needs to handle **unexpected events**	1 2 3 4 5 6 7
2.3 There is a **clearly known way** to do the major types of your work	1 2 3 4 5 6 7
2.4 Your work can rely on **established procedures**	1 2 3 4 5 6 7
2.5 Your work is **routine**	1 2 3 4 5 6 7
2.6 There is an **understandable sequence of steps** that can be followed when doing your work	1 2 3 4 5 6 7

3. To what extent do you agree with the following statements on **task interdependence**?

1- Strongly disagree; 4-Neutral; 7-Strongly agree

3.1 Your work can be performed **fairly independently** of others	1 2 3 4 5 6 7
3.2 Your work can be planned with **little need to coordinate** with others.	1 2 3 4 5 6 7
3.3 Your work requires **frequent coordination** with others (customers, co-workers, supervisors)	1 2 3 4 5 6 7
3.4 You are **rarely required to obtain information from others** to complete this task.	1 2 3 4 5 6 7
3.5 Your work is relatively **unaffected by** others.	1 2 3 4 5 6 7
3.6 Your work is dependent on **receiving information from others**.	1 2 3 4 5 6 7

4.1 Usually, what is the average **time window (from start to finish)** for you to complete a typical task?

No Restriction	Within a week	Within a few days	Within a day	Within a few hours	Within an hour	Within 10 minutes
1	2	3	4	5	6	7

4.2 What is the time **urgency** for you to start or finish your typical task?

Take it easy	Allow delays	Allow a little delay	At normal speed	Better done sooner	Immediate	In a hurry
1	2	3	4	5	6	7

4.3 To what extent do you agree the following statements on the **time criticality** of your task?

1- Strongly disagree; 4-Neutral; 7-Strongly agree

4.3.1 It is very important for you to **start your task on time**	1 2 3 4 5 6 7
4.3.2 It is very important for you to **complete your task on time**	1 2 3 4 5 6 7
4.3.3 It is very important for you to **start your task as soon as possible**	1 2 3 4 5 6 7
4.3.4 It is very important for you to **complete your task as soon as possible**	1 2 3 4 5 6 7

5.1 To what extent do you work at **various locations**?

Always the same locations	-	-	Some at same location, but some at different new locations	-	-	Always at different new locations
1	2	3	4	5	6	7

5.2 To what extent is your job **limited to a specific location**?

At one specific location	-	-	At several alternative locations	-	-	Any place
1	2	3	4	5	6	7

5.3 To what extent do you have the **freedom of choosing a place** to perform your work?

Not at all	-	-	Moderately	-	-	To a great extent
1	2	3	4	5	6	7

5.4 To what extent is the performance of your work **dependent on the information about**:

1. Not at all 4. Moderately 7. To a great extent

5.4.1 **your current location**?	1 2 3 4 5 6 7
5.4.2 **other people's** (such as co-workers or customers) **locations**?	1 2 3 4 5 6 7
5.4.3 The **location of things or equipment** that are related to your work?	1 2 3 4 5 6 7
5.4.4 The **travel or navigation guides** to your destination?	1 2 3 4 5 6 7

6. Please check the **mobile devices** that you are using (you can check more than one) from the list below:
- Pager
- Cell Phone
- Smart Phone (including Blackberry)
- PDA (Personal Digital Assistant)
- Pocket PC
- Laptop Computer
- Two way radio devices
- Specialized mobile device or other. Please specify: ___________________

7. Please check the **networks** that you are using (you can check more than one) from the list below:
- Pager network
- Two way radio
- Cell phone communication network
- Wireless local area network (WiFi)
- Wireless Email network (e.g.Blackberry)
- Fixed-line phone (Public phone or borrowing someone else's phone)
- Other. Please specify: _______________________

Please indicate the **current usage, perceived usefulness, and your intention to use the following mobile technology functions:**

8.1 **Voice communication on cell phone or two way radio** (When you are on the mobile work site or in the car).

To what extent do you **1-Not at all; 4-Moderately; 7- To a great extent**	
8.1.1 **Use it now?**	1 2 3 4 5 6 7
8.1.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.1.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.1.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.1.5 **intend to use** it?	1 2 3 4 5 6 7
8.1.6 **would like to use** it?	1 2 3 4 5 6 7
8.1.7 Think it **should be used**?	1 2 3 4 5 6 7

8.2 Receiving and sending **text message** (short message or email) (When you are on the mobile work site or in the car).

To what extent do you **1-Not at all; 4-Moderately; 7- To a great extent**	
8.2.1 **Use it now?**	1 2 3 4 5 6 7
8.2.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.2.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.2.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.2.5 **intend to use** it?	1 2 3 4 5 6 7
8.2.6 **would like to use** it?	1 2 3 4 5 6 7
8.2.7 Think it **should be used**?	1 2 3 4 5 6 7

8.3 **Batch mode job assignment**/dispatching, recording and reporting **through mobile devices.**

To what extent do you **1-Not at all; 4-Moderately; 7- To a great extent**	
8.3.1 **Use it now?**	1 2 3 4 5 6 7
8.3.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.3.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.3.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.3.5 **intend to use** it?	1 2 3 4 5 6 7
8.3.6 **would like to use** it?	1 2 3 4 5 6 7
8.3.7 Think it **should be used**?	1 2 3 4 5 6 7

8.4 **Real time mobile job assignment and dispatching**, including job monitoring, tracking, and automatic reporting.

To what extent do you	**1-Not at all; 4-Moderately; 7- To a great extent**
8.4.1 **Use it now?**	1 2 3 4 5 6 7
8.4.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.4.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.4.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.4.5 **intend to use** it?	1 2 3 4 5 6 7
8.4.6 **would like to use** it?	1 2 3 4 5 6 7
8.4.7 Think it **should be used**?	1 2 3 4 5 6 7

8.5 **Location tracking – Ability to dynamically identify your current locations. Location related information provision** (such as traffic, gas stations, etc.).

To what extent do you	**1-Not at all; 4-Moderately; 7- To a great extent**
8.5.1 **Use it now?**	1 2 3 4 5 6 7
8.5.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.5.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.5.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.5.5 **intend to use** it?	1 2 3 4 5 6 7
8.5.6 **would like to use** it?	1 2 3 4 5 6 7
8.5.7 Think it **should be used**?	1 2 3 4 5 6 7

8.6 **Travel navigation** (GPS with mapping)

To what extent do you	**1-Not at all; 4-Moderately; 7- To a great extent**
8.6.1 **Use it now?**	1 2 3 4 5 6 7
8.6.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.6.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.6.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.6.5 **intend to use** it?	1 2 3 4 5 6 7
8.6.6 **would like to use** it?	1 2 3 4 5 6 7
8.6.7 Think it **should be used**?	1 2 3 4 5 6 7

8.7 **Notification of time-critical or emergency information** through mobile voice/text communication or built-in functions in mobile devices (When you are on the mobile work site or in the car):

To what extent do you	1-Not at all; 4-Moderately; 7- To a great extent
8.7.1 **Use it now**?	1 2 3 4 5 6 7
8.7.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.7.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.7.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.7.5 **intend to use** it?	1 2 3 4 5 6 7
8.7.6 **would like to use** it?	1 2 3 4 5 6 7
8.7.7 Think it **should be used**?	1 2 3 4 5 6 7

8.8 **Search/access information online,** including enterprise information access (such as sales, inventory and/or customer information), industry information access (such as stock market and real estate industry's multiple listing(MLS)), and mobile Internet access **(When you are on the mobile work site or in the car).**

To what extent do you	1-Not at all; 4-Moderately; 7- To a great extent
8.8.1 **Use it now**?	1 2 3 4 5 6 7
8.8.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.8.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.8.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.8.5 **intend to use** it?	1 2 3 4 5 6 7
8.8.6 **would like to use** it?	1 2 3 4 5 6 7
8.8.7 Think it **should be used**?	1 2 3 4 5 6 7

8.9 Offline transaction functions on mobile devices: **bar code scanning, signature capture, credit card scanning, receipt printing, data entry/recording, etc.** (when you are on the mobile work site or in the car).

To what extent do you	1-Not at all; 4-Moderately; 7- To a great extent
8.9.1 **Use it now**?	1 2 3 4 5 6 7
8.9.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.9.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.9.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.9.5 **intend to use** it?	1 2 3 4 5 6 7
8.9.6 **would like to use** it?	1 2 3 4 5 6 7
8.9.7 Think it **should be used**?	1 2 3 4 5 6 7

8.10 Online transaction functions on mobile devices: **on line order placing, online payment processing, online delivery processing, online appointment arrangement, etc.** when you are on the mobile work site or in the car.

To what extent do yo	**1-Not at all; 4-Moderately; 7- To a great extent**
8.10.1 **Use it now?**	1 2 3 4 5 6 7
8.10.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.10.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.10.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.10.5 **intend to use** it?	1 2 3 4 5 6 7
8.10.6 **would like to use** it?	1 2 3 4 5 6 7
8.10.7 Think it **should be used**?	1 2 3 4 5 6 7

8.11 Mobile office software: **Spreadsheet, Power Point, Word processing, Access or other database applications, Address book, Calendar, etc.** when you are on the mobile work site or in the car.

To what extent do you	**1-Not at all; 4-Moderately; 7- To a great extent**
8.11.1 **Use it now?**	1 2 3 4 5 6 7
8.11.2 perceive it would **increase the productivity** of your work?	1 2 3 4 5 6 7
8.11.3 perceive it would **improve the performance** of your work?	1 2 3 4 5 6 7
8.11.4 perceive it would be **useful** in your work?	1 2 3 4 5 6 7
8.11.5 **intend to use** it?	1 2 3 4 5 6 7
8.11.6 **would like to use** it?	1 2 3 4 5 6 7
8.11.7 Think it **should be used**?	1 2 3 4 5 6 7

9. Which **category** does your work fall in?

- ☐ Managers (at all levels).
- ☐ Sales force (including real estate agents)
- ☐ Mobile professional (consultants, engineers)
- ☐ Transportation/Delivery (including taxi drivers)
- ☐ Field work (repair/maintenance)
- ☐ Public safety (police, security guard)
- ☐ Healthcare personal
- ☐ Others. Please specify: ____________________

10. Please list some benefits that mobile technologies bring to your work?

____

____

End of questionnaire - Thank you!

Appendix C: Regression of Intention to Use on Perceived Usefulness for Field Workers Sample

Dependent Variable	Independent Variable	R^2	Β
Intention to Use Mobile Voice Communication	Perceived Usefulness of Mobile Voice Communication	0.804***	0.896***
Intention to Use Mobile Text Messaging	Perceived Usefulness of Mobile Text Messaging	0.619***	0.787***
Intention to Use Mobile Notification	Perceived Usefulness of Mobile Notification	0.692***	0.832***
Intention to Use Mobile Information Searching	Perceived Usefulness of Mobile Information Searching	0.685***	0.828***
Intention to Use Mobile Off-line Transaction Processing	Perceived Usefulness of Mobile Off-line Transaction Processing	0.733***	0.856***
Intention to Use Mobile Online Transaction Processing	Perceived Usefulness of Mobile Online Transaction Processing	0.763***	0.874***
Intention to Use Location Tracking	Perceived Usefulness of Location Tracking	0.725***	0.851***
Intention to Use Navigation	Perceived Usefulness of Navigation	0.727***	0.852***
Intention to Use Batch Mode Mobile Job Dispatching	Perceived Usefulness of Batch Mode Mobile Job Dispatching	0.769***	0.787***
Intention to Use Real Time Mobile Job Dispatching	Perceived Usefulness of Real Time Mobile Job Dispatching	0.662***	0.814***
Intention to Use Mobile Office	Perceived Usefulness of Mobile Office	0.805***	0.897***

β: Standardized regression coefficients
***: $p<0.001$

Appendix D: Regression of Intention to Use on Perceived Usefulness for Task Characteristics for Mobile Knowledge Workers Sample

Dependent Variable	Independent Variable	R^2	B
Intention to Use Mobile Voice Communication	Perceived Usefulness of Mobile Voice Communication	0.590***	0.768***
Intention to Use Mobile Text Messaging	Perceived Usefulness of Mobile Text Messaging	0.698***	0.835***
Intention to Use Mobile Information Searching	Perceived Usefulness of Mobile Information Searching	0.626***	0.791***
Intention to Use Mobile Notification	Perceived Usefulness of Mobile Notification	0.767***	0.876***
Intention to Use Mobile Off-line Transaction Processing	Perceived Usefulness of Mobile Off-line Transaction Processing	0.517***	0.719***
Intention to Use Mobile Online Transaction Processing	Perceived Usefulness of Mobile Online Transaction Processing	0.669***	0.818***
Intention to Use Location Tracking	Perceived Usefulness of Location Tracking	0.665***	0.816***
Intention to Use Navigation	Perceived Usefulness of Navigation	0.720***	0.848***
Intention to Use Batch Mode Mobile Job Dispatching	Perceived Usefulness of Batch Mode Mobile Job Dispatching	0.643***	0.802***
Intention to Use Real Time Mobile Job Dispatching	Perceived Usefulness of Real Time Mobile Job Dispatching	0.569***	0.754***
Intention to Use Mobile Office	Perceived Usefulness of Mobile Office	0.917***	0.957***

β: Standardized regression coefficients
***: $p<0.001$