Applying the Theory of Task−Technology Fit to Mobile Technology: The Role of User Mobility

Judith Gebauer
University of Illinois at Urbana−Champaign, College of Business

Ya Tang
University of Illinois at Urbana−Champaign, College of Business

Abstract

In this paper, we apply the theory of task technology fit to mobile technology, focusing specifi−cally on the role of user mobility. We describe the results of an empirical study of 216 business users of mobile devices that included various smart phones, personal digital assistants (PDAs), and laptop computers. Our findings suggest that (1) the relationship between task difficulty and functional requirements of the mobile devices is stronger for highly mobile users than for less mobile users; (2) user mobility is associated with increased user−perceived importance of a number of non−functional features; and (3) for a number of functions and features, highly mobile users indicated a stronger relationship between task−technology fit, and overall evaluation of the technology. We conclude that user mobility needs to be taken into account when applying the theory of task−technology fit to mobile information systems. In addition, our study provides spe−cific insights about the information system requirements of an increasingly mobile workforce.

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Judith Gebauer
Assistant Professor of Business Administration
University of Illinois at Urbana-Champaign
College of Business
350 Wohlers Hall
1206 South Sixth Street
Champaign, IL 61820
phone: (217) 244-0330
fax: (217) 244-7969
gebauer@uiuc.edu

Ya Tang
Doctoral Candidate of Business Administration
University of Illinois at Urbana-Champaign
College of Business
350 Wohlers Hall
1206 South Sixth Street
Champaign, IL 61820
yatang2@uiuc.edu

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Abstract

In this paper, we apply the theory of task technology fit to mobile technology, focusing specifically on the role of user mobility. We describe the results of an empirical study of 216 business users of mobile devices that included various smart phones, personal digital assistants (PDAs), and laptop computers. Our findings suggest that (1) the relationship between task difficulty and functional requirements of the mobile devices is stronger for highly mobile users than for less mobile users; (2) user mobility is associated with increased user-perceived importance of a number of non-functional features; and (3) for a number of functions and features, highly mobile users indicated a stronger relationship between task-technology fit, and overall evaluation of the technology. We conclude that user mobility needs to be taken into account when applying the theory of task-technology fit to mobile information systems. In addition, our study provides specific insights about the information system requirements of an increasingly mobile workforce.

Keywords: mobile technology, mobile business applications; mobile workforce; theory of task-technology fit; user mobility; requirements.

1 Introduction

The theory of task-technology fit maintains that a match between business tasks and information technology is important to explain and predict the success of information systems (Goodhue and Thompson, 1995; Zigurs and Buckland, 1998). For various scenarios of task and technology, statistical significance has been established of a positive association between task-technology fit and information system success measures, such as use (Dishaw and Strong, 1999), and impact on individual performance (Goodhue and Thompson, 1995) and on group performance (Zigurs *et al.*, 1999). The concept of task-technology fit promises to help identify aspects that are critical to support a given business task, and can, thus, contribute to the success of technology innovations (Junglas and Watson, 2006). One such innovation is represented by mobile technology to support an increasingly mobile workforce (Barnes, 2003). Upon applying the theory of task-technology fit to mobile information systems, however, it becomes apparent that previous studies have focused mainly on the functionality that is provided by the technology, and have paid less attention to the *context* in which the technology is being used. At the same time, however, usability studies suggest that the use-context may have a non-trivial impact on the conditions of task-technology fit (Perry *et al.*, 2001). First, it can be observed that non-functional features, such as weight and size, play a more prominent role in mobile than in non-mobile use contexts (Gebauer and Ginsburg, forthcoming; Turel, 2006). Second, functional requirements may shift as business tasks are often performed differently in mobile versus non-mobile use contexts (Gebauer and Shaw 2004; Perry *et al.*, 2001; Zheng and Yuan, 2007). As a result of the observable changes of business tasks and related technology requirements, it becomes necessary to assess the applicability of the theory of task-technology fit to mobile technologies and mobile use contexts, and to carefully determine the needs for theory adjustments and extensions (Junglas and Watson, 2006; Lyytinen and Yoo, 2002).

In the current study, we address three research questions: (1) what is the impact of user mobility on the way that a particular task is performed—as reflected in differences of functional requirements between highly mobile and less mobile users?; (2) how does user mobility impact the user-perceived importance of various non-functional features of the technology?; and (3) how does user mobility impact a user's appreciation of the fit between task and technology? We proceed with an outline of the theoretical framework. Subsequently, we describe the empirical study, and present a summary of the results of our data analysis.

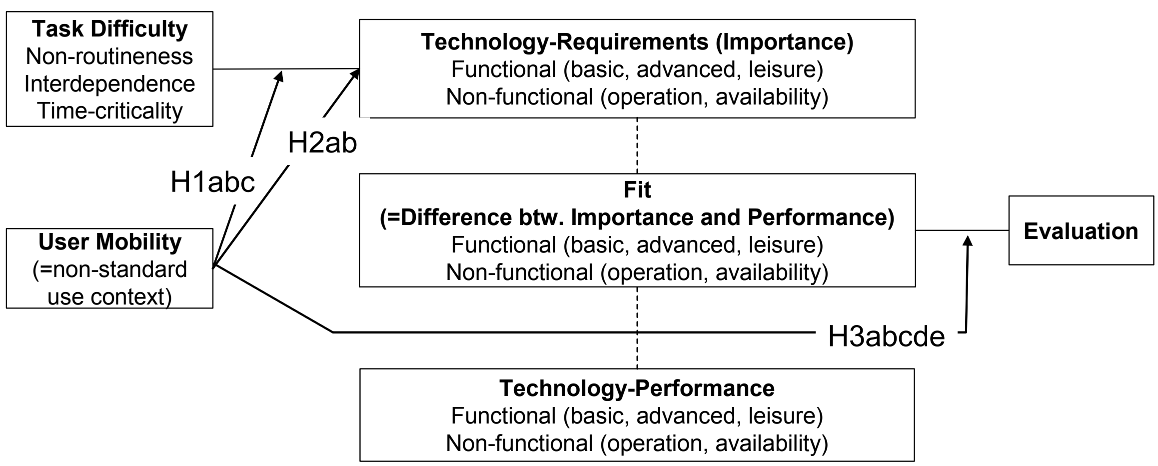
2 Theoretical framework

2.1 Background

According to the theory of task-technology fit the success of an information system should be related to the fit between task and technology, whereby success has been related to individual performance (Goodhue and Thompson, 1995) and to group performance (Zigurs and Buckland, 1998). For group support systems, a specific theory of task-technology fit was developed (Zigurs and Buckland, 1998) and later tested (Zigurs *et al.*, 1999) that detailed the requirements of group support systems to fit group tasks. For mobile information systems, task-technology fit has been shown to be generally relevant (Gebauer and Shaw, 2004), but more specific questions regarding the applicability of task-technology fit to mobile information systems remain unanswered.

As depicted in Figure 1, our research model builds on two basic associations that are discussed and explained in the theory of task-technology fit, namely (a) the association between task characteristics and the need for various functions and features of a technology, and (b) the association between the fit of technology requirements and technology performance, and system evaluation (Dishaw and Strong, 1998), all from the perspective of the user. With Gebauer *et al.* (2006), we model a business task based on its level of difficulty, as characterized by non-routineness, interdependence and time-criticality. Task-technology fit is modelled as the difference between the user-perceived requirements (i.e., importance) regarding various functional and non-functional features and the corresponding performance of the technology. The specific focus of the current research study is on the impact of user mobility on the associations between (a) task difficulty and technology requirements (H1, H2), and (b) between task-technology fit and evaluation (H3).

Figure 1 Research model



2.2 Mobility and functional requirements

The first research question concerns the interaction between user mobility and the way that tasks are performed, as reflected in user-indicated functional requirements of the supporting technology system. Functional requirements are a concept that is used by software engineers, and pertain to the particular behaviours of a software system that are inherent in the different functions that the system can perform (Wiegers, 2003). To the extent that functional requirements determine what the system can do they also determine the extent to which user tasks can be supported. Compared to a non-mobile user, a mobile user might perform tasks more often by delegation than directly, and might experience a greater need to utilize the technology as a proxy to "stay in touch" and to monitor progress (Gebauer and Shaw, 2004; Perry *et al.*, 2001). As a result of such differences, we expect mobile users to rely more heavily on basic communication functionality, such as voice and e-mail, than non-mobile users who are assumed to have reliable and stable access to regular corporate information technology infrastructure, including advanced applications to access and process information. We expect differences in the way that a given task is performed to be reflected in the functionality that users indicate to be important for their work. In addition, we expect differences of the functionality that is not directly related to a task at hand but that is often included in mobile devices, such as pictures, videos, and games.

For a given level of task difficulty, we expect mobile users to have a greater need for basic communication functionality than non-mobile users. We hypothesize:

H1a: Mobility moderates the relationship between task difficulty and user-perceived importance of basic communication functionality, such that the effect will be stronger for mobile users.

With respect to the need for advanced information processing functionality that includes office applications and Internet-access, we expect to find a combination of two effects. First, we expect non-mobile users to have a greater overall need for advanced information processing functionality than mobile users. Given that non-mobile users have ready access to corporate information technology resources, we expect that much of the need will be satisfied with non-mobile information technology (e.g., desktop computers), and not be reflected in stated requirements for mobile information technology. Second, the lack of alternatives that is faced by mobile users who need to perform advanced information processing should be reflected in a greater need for advanced information processing functionality that is provided by a mobile device (even if changes of task structure occur). Expecting that the second effect will at least be partly offset by the first, we hypothesize:

H1b: Mobility moderates the relationship between task difficulty and user-perceived importance of advanced information processing functionality, such that the effect will be stronger for mobile users, but less strong than in the case of basic communication functionality.

Third, we expect functionality that is often not directly related to a given business task, such as video recording, picture taking, and game playing, but that is often provided with mobile devices, to be more important to mobile users than to non-mobile users. The reason is that mobile users may indicate a greater need to utilize leisure-related (i.e., non-task-related) functions to keep busy and entertained during prolonged periods that are spent in a non-office environment, such as during travel and commute. We hypothesize:

H1c: Mobility moderates the relationship between task difficulty and user-perceived importance of leisure-related functionality, such that the effect will be stronger for mobile users.

2.3 Mobility and non-functional requirements

The second research question pertains to the direct association between use-context and non-functional user requirements. Non-functional requirements support the functional aspects of a technology system in a more general sense, and relate to the operation of the system (Wiegers, 2003). Typical non-functional requirements, sometimes also referred to as "ilities", are reliability, scalability, usability, and speed of operation. To the extent that non-functional requirements relate to the conditions of the use context they may impose constraints on the design and implementation of the technology.

In the current study, we expect users that are highly mobile to indicate non-functional features of the technology to be important that are different from the features indicated as important by users that are less mobile (Gebauer and Ginsburg, forthcoming). An obvious reason for such difference is the ability to carry equipment: Technology in support of a mobile user has to be light and small—a feature that is typically less important for a less mobile user. To test this relationship we seek to identify differences in the technology features that mobile and non-mobile users indicate to be important to perform their work.

We distinguish between two types of non-functional features: (a) non-functional features that are related to the operation of the mobile technology, including for example form factors, processor speed and factors that relate to the input (keyboard) and output (screen) components, and (b) non-functional features that relate to the availability of the technology in various use situations. We expect both types of non-functional features to be of higher importance to highly mobile users than to less mobile users, and hypothesize:

H2a: Mobility is positively related with user-perceived importance of operational non-functional features.

H2b: Mobility is positively related with user-perceived importance of non-functional features that enable continuous availability.

2.4 Mobility and the appreciation of task-technology fit

The third research question pertains to the extent to which the use-context impacts the way that a user appreciates fit, a factor that might be related strongly to user-expectations. We assume that when evaluating technology, a user consciously or unconsciously takes into account the specifics and difficulties associated with the mobile versus the non-mobile use context. Given that non-mobile technology is less novel and typically more mature than mobile technology, we expect a user indicating a given level of fit between requirements and technology performance in a mobile use-context to be more satisfied with the technology than a user in a less mobile use-context. In other words, we expect highly mobile users to have a stronger positive relationship between fit and evaluation than less mobile users and hypothesize:

H3a: Mobility moderates the relationship between fit of basic communication functionality and overall evaluation of the technology, such that the effect will be stronger for mobile users.

H3b: Mobility moderates the relationship between fit of advanced functionality and overall evaluation of the technology, such that the effect will be stronger for mobile users.

H3c: Mobility moderates the relationship between fit of leisure-related functionality and overall evaluation of the technology, such that the effect will be stronger for mobile users.

H3d: Mobility moderates the relationship between fit of non-functional operation-related features and overall evaluation of the technology, such that the effect will be stronger for mobile users.

H3e: Mobility moderates the relationship between fit of non-functional availability-related features and overall evaluation of the technology, such that the effect will be stronger for mobile users.

3 Data collection

We collected survey data during a period of eight days at the end of September 2006 in cooperation with CNET.com, a media company that operates an online media website targeting the users of high-technology devices. For sampling, a random intercept technique was used and the survey was presented to 2% of the site's unique visitors, as determined based on a cookie that was given to every visitor of the site. All participants were given the opportunity to participate in a random drawing of a cash prize of $1,000. According to the cooperation partner who administered the survey on our behalf, acceptance rates of the survey were average with about 6%, followed by a slightly lower than usual completion rate (40% versus 50-70%), which might be attributed to the comparatively extensive length of the survey. Of 811 completed surveys 337 qualified, as respondents indicated to be employed, over 18 years of age, and using a wireless device for work-related purposes.

3.1 Variable measures

Web-server generated data provided information regarding the time a respondent took to complete the survey. Assuming that the survey needed at least 5 minutes (300 seconds) to be completed, we excluded 6 surveys for a remaining set of 331 responses. Demographic information that was included in the questionnaire related to gender, age, and residence country. We also asked about job positions and about the mobile devices that respondents used to perform their jobs.

Related to the research model (Appendix A), we inquired about the difficulty of user tasks and about the use environment (mobility): Task difficulty was operationalized with the three factors of non-routineness, interdependence, and time-criticality (Gebauer *et al.*, 2006), and mobility was operationalized with questions about the extent to which a user performed work in a non-standard use environment (Gebauer and Shaw, 2004). Technology requirements were assessed with a number of questions on the importance of functionality and non-functional features that were provided by the primary mobile device. Functionality relates directly to a process that the system has to perform or information the system needs to contain (Wiegers, 2003), and was operationalized as basic communication functionality (voice quality, written communication), advanced information processing functionality (internet access, office applications), and "leisure"-related functionality (photo, video, games, and ring tones) (Gebauer and Ginsburg, forthcoming; Gebauer *et al.*, 2007). Non-functional features relate to behavioural properties of a system (Wiegers, 2003), and were operationalized with a number of factors related to operation, such as form factors (weight, size), input (keyboard, keypad), display (screen), and network reception; and with factors related to availability in various locations and work-related situations, such as airport, car, public transportation; during commute, work on location and meetings; and outside of regular office hours (Gebauer and Ginsburg, forthcoming; Gebauer *et al.*, 2007). Besides questions about the importance of various functions and features, we also asked about user-perceived performance for each item, and used the absolute difference between the two measures to determine fit. The final category related to the overall evaluation of the primary mobile device by the respondent.

3.2 Missing data

Two sources of missing data caused concern in the dataset. First, regarding the variables that were relevant to test our research model 115 responses were incomplete with a total of 454 data cells missing. 216 records were complete, and subsequently retained for further analysis.

A second source of missing data was a result of respondents who indicated “Not Applicable” (N/A) on the questions of how their primary mobile device performed with respect to various functionalities. 131 surveys contained a total of 815 data cells indicating N/A as a response to one or several performance-related questions (Appendix A). In order to retain a sample large enough for further data analysis, we replaced N/A answers with a neutral value indicating performance as: “Neither Positive nor Negative”. Subsequent analysis is based on 216 records.

4 Data analysis

As indicated in Table 1, over two thirds (68%) of the survey participants indicated their age to be between 25 and 44 years. Eighty-seven percent of the respondents were male, and just as many came from North America. Job positions showed more variety, whereby the largest group (31%) indicated to occupy technical staff positions, followed by professionals (19%) and “other management or supervisory” (15%) positions. Motorola was the brand that users most often indicated to be the manufacturer of their primary device (25%), followed by Samsung (13%) and Nokia (13%). The vast majority of the primary devices were smart phones/cell phones (85%), followed by laptops (13%).

Table 1 Demographic data (n=216)

Age	<= 24	5.%
	25 – 34	32%
	35 – 44	36%
	45 – 54	18%
	>= 55	9%
Gender	Male	87%
	Female	12%
Country	North America	87%
	Asia	6%
	Europe	5%
	South America	1%
	Other	1%
Job Position	Executive Management	10%
	Senior Management	3%
	Middle Management	10%
	Other Management or Supervisory	15%
	Technical Staff	31%
	Professional	19%
	Other	12%
Maker of Mobile Device	Dell	6%
	HP	5%
	LG Electronics	5%
	Motorola	26%
	Nokia	13%
	Palm	10%

RIM Blackberry	6%
Samsung	13%
Sony Ericsson	4%
Other	4%
None / Not Applicable	6%
Don't know / Not sure	3%

4.1 Structural equation modelling

To test the research model, we used structural equation modelling (SEM). The major reason to choose this statistical technique was that it allows assessing the relationships in the measurement model and in the structural model at the same time, which makes it very suitable to analyze complex models (Gefen *et al.*, 2000). SEM incorporates the measurement error in the latent variables that we do not measure directly, and assesses the relationships among the latent variables simultaneously.

4.2 PLS Graph 3.0

The partial least square (PLS) estimation method was used to assess the impact of mobility on various functional and non-functional technology requirements, on the relationships between task difficulty and technology requirements, and on the relationships between fit and the overall evaluation of the mobile devices (Figure 1). In the context of the current study, PLS has several advantages over covariance based SEM methods (Gefen *et al.*, 2000). First, PLS is generally better suited for theory development where pre-validated variable constructs may not be available, such as in our case. Second, PLS does not rely on the assumption of a normal distribution of variables, which was a concern in our study as well. Third, PLS makes it easy to test moderated relationships. In our conceptual model, we hypothesized that mobility moderates the relationships between task difficulty and user-perceived technology requirements, and between fit and overall evaluation of the mobile devices. Fourth, PLS can apply both reflective and formative modelling, whereby we consider a formative model to be more appropriate for our study. Reflective indicators are viewed as affected by the underlying latent variable, and as a result covariate with the latent variable. In comparison, formative indicators are believed to cause changes in the latent variable. Consequently, the indicators in formative models will approximate the underlying construct in combination, whereby individual weights are determined according to the relative importance in forming the construct. Formative indicators are not necessary correlated, as would be expected in a reflective model (Diamantopoulos and Winklhofer 2001). A good example for formative indicators is provided by the measurements that are included in the assessment of Social Economic Status (SES), such as gender, age, education, income, and occupation (Hauser 1973). Any change in the measurement items can result in a change of SES, but the individual indicators may not be correlated.

In our model, the indicators underlying the latent variables of task difficulty, mobility, technology requirements, technology performance, and fit are all modelled as formative indicators based on the assumption that the indicators measure different aspects of the latent variable, and are not necessarily correlated. For formative models, many of the traditional tests to determine the quality of the model variables are not applicable, including tests for internal reliability, and discriminant and convergent validity (Churchill, 1979; Straub *et al.*, 2004). Alternative, suggested approaches to develop high-quality formative variables include the solicitation of input from experts, including user surveys (Diamantopoulos and Winklhofer, 2001; Rossiter, 2002), whereby it is important to ensure that the indicators as much as possible exhaust the variable's domain (Diamantopoulos, 2006). In the current study, the variables associated with technology requirements, performance and fit, all include indicators that were identified in a content analysis of online user-reviews (Gebauer and Ginsburg, forthcoming; Gebauer *et al.*, 2007). Descriptive statistics are provided in Appendix B. Table 1 shows the estimated coefficients of the measurement items, together with standard error and t-statistics. All items range from 1 to 7, with the exception of indicators for overall evaluation – the scale of which ranges from 1 to 5.

Table 1 Measurement Model

	Estimated Coefficient (Weight)	**Standard Error**	**T-Statistic**
Task Difficulty			
NonRoutineness	0.2	0.46	0.42
Interdependence1	-0.57	0.36	1.58
Interdependence2	0.81*	0.46	1.78
TimeCriticality1	0.56	0.35	1.62
TimeCriticality2	0.05	0.35	0.13
User Mobility			
Mobility1	0.53***	0.12	4.48
Mobility2	0.44***	0.05	9.56
Mobility3	0.25**	0.12	2.01
Technology Requirements – Basic Communication Functionality			
R_Voice	-0.01	0.46	0.02
R_Written	1.00***	0.19	5.24
Technology Requirements – Advanced Functionality			
R_Internet	0.84	0.52	1.6
R_Office	0.23	0.61	0.37
Technology Requirements – Leisure-Related Functionality			
R_Photo	1.02**	0.46	2.23
R_Video	0.04	0.45	0.08
R_Game	-0.18	0.43	0.42
R_RingTones	-0.7	0.51	1.36
Technology Requirements – Operation-Related Non-Functional Features			
R_FormFactor	0.03	0.21	0.15
R_Input	-0.16	0.23	0.68
R_Display	0.08	0.28	0.27
R_Network	0.29	0.2	1.46
R_Compatibility	0.34	0.23	1.47
R_MultiFunctionality	-0.2	0.29	0.68

R_Battery	0.09	0.27	0.34
R_Speed	-0.03	0.28	0.11
R_Storage	-0.27	0.32	0.85
R_EaseOfUse	-0.04	0.24	0.16
R_HandsFree	-0.22	0.24	0.92
R_Durability	0.04	0.24	0.18
R_Customization	-0.16	0.25	0.65
R_Automation	0.79***	0.21	3.78
R_CustomerService	0.32	0.21	1.49
R_Sound	-0.44**	0.21	2.11
R_Security	-0.02	0.2	0.11
Technology Requirements – Availability			
R_Airports	0.21	0.28	0.75
R_Commute	0.24	0.28	0.85
R_InCar	-0.13	0.29	0.45
R_OutsideRregularOfficeHours	0.52**	0.23	2.25
R_OnSite	0.61***	0.22	2.86
R_PublicTransport	-0.11	0.23	0.5
R_Meetings	-0.17	0.26	0.64
Fit – Basic Communication Functionality†			
F_Voice	0.81***	0.24	3.33
F_Written	0.47*	0.25	1.86
Fit – Advanced Functionality†			
F_Internet	0.89***	0.28	3.13
F_Office	0.24	0.46	0.52
Fit – Leisure-Related Functionality†			
F_Photo	1.05***	0.18	5.76
F_Video	-0.33	0.31	1.08
F_Game	-0.17	0.31	0.54
F_RingTones	0.08	0.33	0.23
Fit – Operation-Related Features†			
F_FormFactor	0.03	0.21	0.16
F_Input	-0.19	0.2	0.95
F_Display	0.31	0.19	1.62
F_Network	0.16	0.19	0.82
F_Compatibility	0.29*	0.17	1.74
F_MultiFunctionality	0.21	0.22	0.94
F_Battery	0.50*	0.26	1.95
F_Speed	0.26	0.2	1.28
F_Storage	0.03	0.19	0.14
F_EaseOfUse	-0.09	0.17	0.49

F_HandsFree	0.3	0.2	1.49
F_Durability	-0.08	0.2	0.38
F_Customization	-0.17	0.18	0.93
F_Automation	0.22	0.23	0.93
F_CustomerService	-0.07	0.19	0.39
F_Sound	0.22	0.22	1.02
F_Security	-0.12	0.23	0.52
Fit –Availability†			
F_Airports	0.18	0.22	0.83
F_Commute	-0.01	0.3	0.02
F_InCar	0.24	0.2	1.2
F_OutsideRegularOfficeHours	0.23	0.25	0.93
F_OnSite	0.01	0.28	0.03
F_PublicTransport	-0.35	0.22	1.62
F_Meetings	0.52**	0.21	2.43
Overall Evaluation			
OverallEvaluation	1	0	0

† For each item, fit was calculated as the absolute difference between technology requirement (importance) and technology performance (user-perceived).
* p<0.10, ** p<0.05, *** p<0.01

The weights of the formative indicators in the measurement model depict the relative importance of the indicators in defining the formative constructs. While no minimum threshold values for indicator weights have been established, the T-statistics can be used to determine the relative importance of the individual formative indicators. Table 1 shows that based on the T-statistics *Interdependence2* was the only indicator of task difficulty that was statistically significant at the p<0.1-level. All three measurement items of the mobility construct (*Mobility1*, *Mobility2*, *Mobility3*) carried significant weight at the p<0.05-level. Regarding the functionality constructs, we note that written communication (*R_Written)* is the dominant measurement item of basic communication requirements, as is photo-related functionality (*R_Photo*) for leisure-related functional requirements. For the non-functional requirements, we note similar results with only two items showing significant weight for each of the two latent constructs of non-functional requirements related to operations and related to availability—automation (*R_Automation*) and sound (*R_Sound*); and outside of regular office hours (*R_OutsideRegularOfficeHours*) and on site (*R_OnSite*). Lastly, a similar picture emerges for the measurement items of fit, each calculated as the absolute difference between corresponding importance (requirement) and performance items: Voice (*F_Voice*) and written communications (*F_Written*) are significant measures of fit for basic communication; internet (*F_Internet*) is a significant measure of fit for advanced functionality. Photo (*F_Photo*) is a significant measure of fit for leisure-related functionality; compatibility (*F_Compatibility*) and battery (*F_Battery*) exhibit significant weight for the fit of non-functional operation-related features; whereas meetings (*F_Meetings*) is a significant measure of fit of non-functional availability-related features at the p<0.05-level.

In all, the quality of the measurement model is limited, which may be attributed in particular to the large number of measurement items for some of the latent constructs, and perhaps the single item measure of the dependent variable. In light of the exploratory characteristic of the current study, we went ahead nevertheless and tested the hypotheses with a structural model; yet we need to keep in mind the limitation associated with the measurement model when discussing our results in section 5.

4.3 Hypotheses testing

We tested the hypothesized relationships between the latent variables of the model in two steps. First, we tested the interaction between task difficulty and mobility with respect to the functional and non-functional technology requirements (Table 2). Then, we tested the interaction between fit and mobility with respect to the overall evaluation of the mobile devices (Table 3). The reason for the two-step testing procedure is that the various indicators for fit have been calculated as the absolute difference between the technology requirements and performance of the respective items, which limits the conceptual value of an estimation of the full model.

As indicated in Table 2, the interaction between task difficulty and mobility is significant with respect to the technology requirements of basic communication functionality, advanced functionality and leisure-related functionality. In our dataset, highly mobile users indicate a stronger association between task difficulty and the importance of basic, advanced, and leisure-related functionality than less mobile users. In other words, for the same level of task difficulty, highly mobile users indicate it to be more important to have basic, advanced and leisure-related functionality in their mobile devices All of H1a, H1b, and H1c are supported. In addition, the path coefficient for basic communication functionality (H1a) is indeed stronger than the path coefficient for advanced information processing functionality (H1b), supporting our suggested relationship between H1a and H1b.

Our data also suggest that mobility has an effect on the user-perceived importance of non-functional operational and availability features. Highly mobile users have a greater need for operation-related non-functional features and a greater need for availability related features than less mobile users. H2a and H2b are supported.

Table 2 Testing of hypotheses H1abc, and H2ab

	Basic functionality		**Advanced functionality**		**Leisure-related Functionality**		**Operation-related non-functional features**		**Availability-related non-functional features**	
	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
Task Difficulty (TD)	0.194	1.594	0.089	0.743	-0.127	0.651				
Mobility (M)	0.035	0.500	0.076	0.903	-0.013	0.148	0.323***	3.448	0.292***	6.135
Interaction: TD*M	0.311**	2.053	0.252**	2.100	0.332*	1.900				
R^2	0.152		0.080		0.115		0.104		0.085	

* p<0.10, ** p<0.05, *** p<0.01

Table 3 Testing of hypotheses H3abcde

	Overall evaluation	
	Coefficient	**T-statistics**
Fit of basic communication functionality (FBF)	0.030	0.489
Fit of advanced functionality (FAF)	0.060	1.098
Fit of leisure-related functionality (FLF)	0.043	0.831
Fit of operation-related non-functional features (FOF)	0.132	1.607
Fit of availability-related non-functional features (FAV)	0.080	1.296
Mobility (MOB)	-0.121	1.384
Interaction: FBF*MOB	0.000	0.000
Interaction: FAF*MOB	-0.005	0.064
Interaction: FLF*MOB	0.14**	2.400
Interaction: FOF*MOB	0.374**	2.463
Interaction: FAV*MOB	0.237**	2.071
R^2	0.396	

* p<0.10, ** p<0.05, *** p<0.01

For our third set of hypotheses, we expected mobility to moderate the relationships between fit and overall evaluation. As detailed in Table 3, the testing results show that the moderating effects between mobility and fit of leisure-related functionality, operational and always-on non-functional features were significant. Highly mobile users with similar levels of fit for leisure functionality, operational and availability non-functional features rated the overall performance of the mobile device higher than less mobile users. H3c, H3d, and H3e are supported. However, mobility does not seem to moderate the relationships between overall evaluation, and fit of basic communication functionality and fit of advanced functionality. H3a and H3b are not supported. Perhaps the lack of difference between mobile and non-mobile users regarding the overall evaluation that is associated with similar levels of fit is the result of increased technology maturity, inasmuch as the expectation regarding the ability of information systems to support a mobile user are now similar to the expectations of information systems that are used in a non-mobile context. However, more research is required before we can fully understand the reasons for the lack of interaction between mobility, fit for basic and advanced functionality and overall evaluation. Table 4 summarizes our findings.

Table 4 Summary of findings

H1a	Mobility moderates the relationship between task difficulty and user-perceived importance of basic communication functionality, such that the effect will be stronger for mobile users.	Supported
H1b	Mobility moderates the relationship between task difficulty and user-perceived importance of advanced information processing functionality, such that the effect will be stronger for mobile users but less strong than in the case of basic communication functionality.	Supported
H1c	Mobility moderates the relationship between task difficulty and user-perceived importance of non-task-related (leisure-related) functionality, such that the effect will be stronger for mobile users.	Supported

H2a	Mobility is positively related with user-perceived importance of operational non-functional features.	Supported
H2b	Mobility is positively related with user-perceived importance of non-functional features that enable continuous availability.	Supported
H3a	Mobility moderates the relationship between fit of basic communication functionality and overall evaluation of the technology, such that the effect will be stronger for mobile users.	Not Supported
H3b	Mobility moderates the relationship between fit of advanced functionality and overall evaluation of the technology, such that the effect will be stronger for mobile users.	Not Supported
H3c	Mobility moderates the relationship between fit of leisure-related functionality and overall evaluation of the technology, such that the effect will be stronger for mobile users.	Supported
H3d	Mobility moderates the relationship between fit of non-functional operation-related features and overall evaluation of the technology, such that the effect will be stronger for mobile users.	Supported
H3e	Mobility moderates the relationship between fit of non-functional availability-related features and overall evaluation of the technology, such that the effect will be stronger for mobile users.	Supported

5 Conclusions and outlook

The current study is part of an ongoing stream of research work studies seeks to identify the technology requirements of an increasingly mobile workforce, as well as to improve our understanding about the success factors and impacts of mobile technology on user performance (Fouskas, 2005; Yuan and Zhang, 2003). We build in particular on the research results of earlier studies that have (1) discussed the applicability of the theory of task-technology fit to mobile information systems (Gebauer *et al.*, 2006), whereby we highlight the role of the use-context; and that have (2) identified a number of technology-related requirements based on content analyses of user-reviews (Gebauer and Ginsburg, forthcoming; Gebauer *et al.*, 2007). Data from an empirical study of 216 professional users of various mobile devices, including smart cell-phones, personal digital assistants (PDAs), and laptop computers, suggested that: (1) the relationship between task difficulty and functional requirements of the mobile devices is stronger for highly mobile users than for less mobile users; (2) higher user mobility is associated with increased user-perceived importance of a number of non-functional features; and (3) for leisure-related functionality and for a number of non-functional features, highly mobile users indicated a stronger relationship between (a) the fit between requirements and technology performance, and (b) the overall evaluation of the technology, than less mobile users.

Reflecting its exploratory nature, the current study has a number of limitations that point to the need for further research and additional analysis. First, the dataset included a substantial amount of missing values, and N/A values that were replaced by the neutral value of 4 on a seven-point Likert scale, whereby other options could have been considered also. Second, we noted limited statistical significance of a large number of items in the measurement-model. In contrast to reflective constructs, guidelines for the development of high-quality formative constructs are much less widely available—a result of the inherent difficulty that is associated with the development of such constructs (Diamantopoulos, 2006). The results of our study contribute to ongoing efforts to utilize input from subject matter experts, including technology users, to improve the external validity of formative constructs (Diamantopoulos and Winklhofer, 2001; Rossiter, 2002). Our findings point to the need to continue efforts to improve the measurement of user-perceived technology requirements, both in relation with user-tasks and use-context. Third, our results suggest a need for additional research on the aspect of user mobility. As a theoretical construct that is central to mobile technology, user mobility is not yet well understood. While the results of our study emphasize the need to consider the use-context when applying information system theories, the construct that was used in the current study may be incomplete, as it focused primarily on travel. In a series of interviews that we conducted since the completion of the current study, we found indications of a more complex construct that needs to include non-travel related mobility, relating for example to time spent in meetings and during commute. Fourth, we used a very particular measure for fit as we calculated the absolute difference of technology requirements and performance. The use of the fit measure in the current study is based on two assumptions: (1) a symmetric relationship exists between fit and the dependent variable of overall evaluation, and (2) a linear relationship exists between fit and overall evaluation. While both assumptions are in line with previous approaches to fit, a closer look at our dataset indicates some need for caution. Additional research studies of the fit-concept promise to contribute not only to the research discipline of mobile technology, but also to contingency theory where "fit" is a central construct.

Despite its limitations, the current study provides valuable insights for the application and extension of the theory of task-technology fit to a mobile use context. Specifically, our findings suggest a need to include into the analysis of mobile technology a well-refined concept of the mobile use context und user mobility; and provide insights about a number of task- and technology-related aspects that are of importance to an increasingly mobile workforce.

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Appendix A – Survey instrument

Task-difficulty

Responses are on a 7 point Likert-scale with anchors 1: strongly disagree, 7: strongly agree.

Non-routineness

(1) I process information from many different sources (*NonRoutineness*)

Interdependence

(1) My job is interdependent with the jobs of other individuals and organizational units (*Interdependence1*)

(2) I interact closely with and rely on the work of others (*Interdependence2*)

Time-criticality

(1) My job frequently requires that I make immediate decisions and actions (*TimeCriticality1*)

(2) Emergency situations and "fire drills" occur often in my job (*TimeCriticality2*)

User mobility

Responses are on a 7 point Likert-scale with anchors 1: strongly disagree, 7: strongly agree.

(1) I frequently perform my job outside of a standard office environment (*Mobility1*)

(2) I frequently work away from an office environment for long periods of time, days or weeks (*Mobility2*)

(3) I am frequently in places that are very far away from my office due to international or cross-country travel (*Mobility3*)

Technology requirements

How important to you are the following functionalities of your primary wireless device? Responses are on a 7 point Likert-scale with anchors 1: not important at all, 7: extremely important.

Basic communication functionality

(1) Voice quality (*R_Voice*)

(2) Written communication including email, instant messaging and multimedia messaging (*R_Written*)

Advanced functionality

(1) Access to the Internet for information and data (R_*Internet*)

(2) Office applications such as word processing, presentation, spreadsheet, and database (*R_Office*)

Leisure-related functionality

(1) Photo imaging applications like making movies and taking / sharing photos (*R_Photo*)
(2) Video entertainment such as viewing TV and movies (*R_Video*)
(3) Game playing (*R_Game*)
(4) Ring tones (*R_RingTones*)

Operation and performance (non-functional features)

Tell us how important the following features of your primary wireless device are to you. Responses are on a 7 point Likert-scale with anchors 1: not important at all, 7: extremely important.

(1) Form factors (weight, size) (*R_FormFactor*)
(2) Components to enter data (keyboard, keypad, mouse, scroll-wheel, stylus) (*R_Input*)
(3) Display (size, resolution) (*R_Display*)
(4) Network access and reception (*R_Network*)
(5) Links with your other devices (compatibility, ability to synchronize) (*R_Compatibility*)
(6) Ability to perform many different functions (*R_MultiFunctionality*)
(7) Battery power (*R_Battery*)
(8) Speed of operation (*R_Speed*)
(9) Storage (memory, hard-drive, other drives) (*R_Storage*)
(10) Ease of use (*R_EaseOfUse*)
(11) Hands-free (Bluetooth, voice dialing) (*R_HandsFree*)
(12) Durability (*R_Durability*)
(13) Customization (menus, backgrounds, alerts) (*R_Customization*)
(14) Automation (automatic time changes, light-sensing) (*R_Automation*)
(15) Customer service (manufacturer, retailer, service provider) (*R_CustomerService*)
(16) Sound (speakers) (*R_Sound*)
(17) Security (*R_Security*)

Availability (non-functional features)

How important is it that your primary device performs well in each of the following situations? Responses are on a 7 point Likert-scale with anchors 1: not important at all, 7: extremely important.

(1) In airports / for airplane travel (*R_Airports*)
(2) Commuting including trips between my home, office, and client sites (*R_Commute*)
(3) While in a car (*R_InCar*)
(4) While performing my job outside of regular office hours, for example during weekends and on vacations (*R_OutsideRegularOfficeHours*)
(5) In situations where I perform my job "on location" including field work and client visits (*R_OnSite*)
(6) On public transportation, such as a bus, subway or train (*R_PublicTransport*)
(7) While participating in meetings and while in the office during the work day (*R_Meetings*)

<u>Technology performance</u>

How would you rate the performance of your primary wireless device on these functionalities? Responses are on an 8 point Likert-scale with anchors 1: performs extremely poorly, 7: performs extremely poorly, and 8: not applicable)

Basic communication functionality

(1) Voice quality (*P_Voice*)

(2) Written communication including email, instant messaging and multimedia messaging (*P_Written*)

Advanced functionality

(1) Access to the Internet for information and data (*P_Internet*)

(2) Office applications such as word processing, presentation, spreadsheet, and database (*P_Office*)

Leisure-related functionality

(1) Photo imaging applications like making movies and taking / sharing photos (*P_Photo*)

(2) Video entertainment such as viewing TV and movies (*P_Video*)

(3) Game playing (*P_Game*)

(4) Ring tones (*P_RingTones*)

Operation and performance (non-functional features)

Would you agree that you are very satisfied with the following features of your primary wireless device? Responses are on a 7 point Likert-scale with anchors 1: strongly disagree, 7: strongly agree.

(1) Form factors (weight, size) (*P_FormFactor*)

(2) Components to enter data (keyboard, keypad, mouse, scroll-wheel, stylus) (*P_Input*)

(3) Display (size, resolution) (*P_Display*)

(4) Network access and reception (*P_Network*)

(5) Links with your other devices (compatibility, ability to synchronize) (*P_Compatibility*)

(6) Ability to perform many different functions (*P_MultiFunctionality*)

(7) Battery power (*P_Battery*)

(8) Speed of operation (*P_Speed*)

(9) Storage (memory, hard-drive, other drives) (*P_Storage*)

(10) Ease of use (*P_EaseOfUse*)

(11) Hands-free (Bluetooth, voice dialing) (*P_HandsFree*)

(12) Durability (*P_Durability*)

(13) Customization (menus, backgrounds, alerts) (*P_Customization*)

(14) Automation (automatic time changes, light-sensing) (*P_Automation*)

(15) Customer service (manufacturer, retailer, service provider) (*P_CustomerService*)

(16) Sound (speakers) (*P_Sound*)

(17) Security (*P_Security*)

Availability (non-functional features)

How would you rate the performance of your primary wireless device in each of the following situations? Reponses are on an 8 point Likert-scale with anchors: 1 performs extremely poorly, 7: performs extremely well, 8: not applicable.

(1) In airports / for airplane travel (*P_Airports*)

(2) Commuting including trips between my home, office, and client sites (*P_Commute*)

(3) While in a car (*P_InCar*)

(4) While performing my job outside of regular office hours, for example during weekends and on vacations (*P_OutsideRegularOfficeHours*)
(5) In situations where I perform my job "on location" including field work and client visits (*P_OnSite*)
(6) On public transportation, such as a bus, subway or train (*P_PublicTransport*)
(7) While participating in meetings and while in the office during the work day (*P_Meetings*)

<u>Evaluation</u>
(1) How would you rate the overall quality of your primary wireless device? Responses on a 5 point Likert-scale with anchors 1: poor, 5: excellent (*Overall Evaluation*)

Appendix B – Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Task difficulty					
NonRoutineness	216	1	7	6.06	1.20
Interdependence1	216	1	7	5.25	1.78
Interdependence2	216	1	7	5.42	1.76
TimeCriticality1	216	1	7	5.73	1.33
TimeCriticality2	216	1	7	4.17	2.15
User mobility					
Mobility1	216	1	7	4.71	2.11
Mobility2	216	1	7	3.44	2.11
Mobility3	216	1	7	2.87	2.07
Technology requirements – Basic communication functionality					
R_Voice	216	1	7	6.17	1.26
R_Written	216	1	7	5.36	1.96
Technology requirements – Advanced functionality					
R_Internet	216	1	7	4.87	1.66
R_Office	216	1	7	4.62	1.55
Technology requirements – Leisure-related functionality					
R_Photo	216	1	7	3.60	2.04
R_Video	216	1	7	2.87	1.94
R_Game	216	1	7	2.46	1.66
R_RingTones	216	1	7	3.60	1.96
Technology requirements – Operation-related non-functional features					
R_FormFactor	216	1	7	5.75	1.27
R_Input	216	1	7	5.30	1.70
R_Display	216	1	7	5.89	1.23
R_Network	216	1	7	6.36	1.20
R_Compatibility	216	1	7	5.49	1.68
R_MultiFunctionality	216	1	7	5.41	1.64
R_Battery	216	1	7	6.47	0.92
R_Speed	216	1	7	6.09	1.13

R_Storage	216	1	7	5.49	1.53
R_EaseOfUse	216	1	7	6.19	1.14
R_HandsFree	216	1	7	5.46	1.62
R_Durability	216	1	7	6.37	1.07
R_Customization	216	1	7	4.88	1.66
R_Automation	216	1	7	5.16	1.69
R_CustomerService	216	1	7	5.57	1.49
R_Sound	216	1	7	5.10	1.82
R_Security	216	1	7	5.70	1.37
Technology requirements – availability					
R_Airports	216	1	7	5.48	1.88
R_Commute	216	1	7	6.04	1.43
R_InCar	216	1	7	5.68	1.64
R_OutsideRegularOfficeHours	216	1	7	6.06	1.39
R_OnSite	216	1	7	6.12	1.39
R_PublicTransport	216	1	7	5.10	1.99
Meetings	216	1	7	5.55	1.63
Technology performance – Basic communication functionality					
P_Voice	216	1	7	5.12	1.50
P_Written	216	1	7	5.08	1.58
Technology performance – Advanced functionality					
P_Internet	216	1	7	4.87	1.66
P_Office	216	1	7	4.62	1.55
Technology performance – Leisure-related functionality					
P_Photo	216	1	7	4.26	1.37
P_Video	216	1	7	4.15	1.34
P_Game	216	1	7	4.00	1.34
P_RingTones	216	1	7	4.40	1.60
Technology performance – Operation-related non-functional features					
P_FormFactor	216	1	7	5.41	1.39
P_Input	216	1	7	4.65	1.73
P_Display	216	1	7	5.35	1.43
P_Network	216	1	7	5.20	1.44
P_Compatibility	216	1	7	4.62	1.77
P_MultiFunctionality	216	1	7	4.79	1.70
P_Battery	216	1	7	4.91	1.61
P_Speed	216	1	7	5.12	1.51
P_Storage	216	1	7	4.80	1.66
P_EaseOfUse	216	1	7	5.48	1.30
P_HandsFree	216	1	7	4.77	1.70
P_Durability	216	1	7	5.41	1.33
P_Customization	216	1	7	4.71	1.51
P_Automation	216	1	7	4.68	1.59
P_CustomerService	216	1	7	4.75	1.58

P_Sound	216	1	7	4.64	1.56
P_Security	216	1	7	4.94	1.45
Technology performance – Availability					
P_Airports	216	1	7	5.21	1.39
P_Commute	216	1	7	5.50	1.31
P_InCar	216	1	7	5.38	1.36
P_OutsideRegularOfficeHours	216	1	7	5.64	1.30
P_OnSite	216	1	7	5.56	1.24
P_PublicTransportation	216	1	7	5.06	1.32
P_Meetings	216	1	7	5.54	1.31
Overall evaluation					
OverallEvaluation	216	1	5	3.81	0.78

Biographical notes: Judith Gebauer is currently an assistant professor of Information Systems at the Department of Business Administration, College of Business at the University of Illinois at Urbana-Champaign. Her research focuses on the management and assessment of emerging technology to support organizational processes and interorganizational relationships. She has published or papers accepted for publication in journals, such as *Communications of the ACM, Journal of the Association for Information Systems*, *International Journal of Electronic Commerce*, *Electronic Markets – The International Journal*, *Information Technology and Management*, and *Informatik Forschung und Entwicklung*, *Information Systems and e-Business Management*, and *Information Systems Management*. For more information, please see www.judithgebauer.com.

Ya Tang is currently a doctoral candidate of Information Systems at the Department of Business Administration, College of Business at the University of Illinois at Urbana-Champaign. Her research interests include features and adoption of mobile information systems, economics of online communities and e-services. Her work has been presented at the Hawaii International Conference on System Sciences, the American Conference on Information Systems, the International Conference on Mobile Business, the Information Resources Management Association International Conference and the Hong Kong Mobility Roundtable and published in the *Journal of Information Technology Theory and Application*.