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Abstract

This study offers a new perspective on the task-technology fit (TTF) paradigm. In contrast to prior research, we conceptualize and empirically validate TTF based on nonlinear and atomistic approaches. More specifically, we investigate how the quantitative fit between individual employees' need for a number of technological functions in a range of applications (e.g., communication, documentation, and administrative applications) and the supply of such resources affects perceived IS use and task performance. Furthermore, we contrast the various types of fit based on their location on the equilibrium points, and examine how different degrees of fit affect perceived IS use and task performance. A three-dimensional model is used to enhance our understanding of the dynamic and complex nature of the effects of TTF on performance. Our key findings suggest that TTF achievement brings IS use and IT-enabled task performance to their optimum levels. In addition, TTF at the high end of the equilibrium point is superior to that of the low end for the purposes of performance. Based on these results and the refined conceptual and methodological framework used, we identify and discuss the implications of our findings for management of IT-related resources.

Keywords*: Task-Technology Fit, Nonlinear Models, Atomistic Approach, Task Performance, Perceived IS Use, Polynomial Regression Analysis, Response Surface Methodology.*

* Hock Hai Teo was the accepting senior editor. This article was submitted on August 23, 2011 and went through 2 revisions.

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Are All Fits Created Equal? A Nonlinear Perspective on Task-Technology Fit

1. Introduction

The notion of fit emerged from population ecology (Campbell, 1969) and contingency theory (Van de Ven, 1979; Van de Ven & Drazin, 1985) as a primary means for conveying theory development and methodological advancement in various scholarly domains (e.g., information systems, management, natural science, psychology, and sociology). Many conceptualizations and methodological manifestations have evolved along different paths. However, most of the organizational studies that are grounded in fit theory have focused on the extent to which "the congruence, match, agreement, or similarity between two conceptually distinct constructs" (Edwards, 1994, p. 51) affects the performance of individuals, teams, and firms.

Over the past decade, fit has entered the vocabulary of many areas of research in information systems (IS), which has resulted in business strategy-IT strategy fit studies (e.g., Chan, Huff, Barclay, & Copeland, 1997; Chan, 2002; Floyd & Wooldridge, 1990; Grover & Sabherwal, 2007; Oh & Pinsonneault, 2007; Roepke, Agarwal, & Ferrat, 2000; Sabherwal, Goles, & Hirschheim, 2001), business planning-IT planning fit studies (Lederer & Mendelow, 1989; Teo & King, 1997), and task-technology fit (TTF) studies (e.g., Dennis, Wixom, & Vandenberg, 2001; Dishaw & Strong, 1999; Goodhue, 1995; Goodhue & Thompson, 1995; Maruping & Agarwal, 2004; Mathieson & Keil, 1998; Vessey & Galletta, 1991; Zigurs & Buckland, 1998). One common finding that has emerged from the numerous studies in these areas is that the extent to which IT strategies or supporting technologies are aligned with business strategies or individual tasks has significant implications for performance.

However, with a few exceptions (e.g., Oh & Pinsonneault (2007) and Venkatesh & Gopal (2010)), TTF studies have assumed, without compelling theoretical justification, that there is a linear association between fit and performance. When viewed in terms of linear conceptualization, output (i.e., performance) is directly proportional to input (i.e., the extent of the fit). Because of the ease and simplicity with which a research framework can be designed and implemented, the linear approach has been widely applied in all scientific disciplines (Day, 1993). According to Venkatesh and Goyal (2010), however, linear models are not suitable for capturing the complexities that are involved in theories of congruence. These authors call for a more nuanced, nonlinear investigation that enhances our understanding of the relationship between fit and performance. The TTF literature also pays little attention to the size and position of fit—it is most often treated as a single, inactive, and unvarying state. The present study challenges this view by suggesting the existence of multiple states of fit and demonstrating that different degrees of fit have diverse effects on task performance.

In this study, we conceptualize and empirically validate the effects that TTF has on task performance through the prism of nonlinearity. Although a linear approach is more common, nonlinear theorizing is often used in management studies, particularly when assessing the effects of resource allocation on performance at a variety of levels (i.e., the individual, the group, and the firm). For example, the slack resource theory (Bourgeois, 1981; Cyert & March, 1963) suggests that the relationship between resource allocation and performance outcomes follows a curvilinear pattern and takes a parabolic form, "∩" (Bourgeois, 1981; Nohria & Gulati, 1996; Sharfman, 1988). According to this view, an optimal outcome of resource allocation can be achieved in the mid-range rather than on the high or low ends of the continuum. Consequently, both too much and too little resource allocation could lead to adverse consequences (Bourgeois, 1981). Since technology is a resource that is critical to a firm's success, and TTF is the outcome of resource allocation, the nonlinear approach is suitable for understanding the complexities and dynamics of TTF's effects. Furthermore, the theoretical foundation of the slack resource framework is analogous to that of TTF, which indicates that both technology surpluses and deficits have sub-optimal consequences.

Production theory also suggests that a nonlinear approach is more precise than a linear one in portraying the structural effectiveness of resource distribution on performance. Many studies on IT business values (e.g., Brynjolfsson & Hitt, 1996; Hitt & Brynjolfsson, 1996) have adopted the Cobb-Douglas production function in order to estimate the impact of IT resources (input) on performance (output) in a nonlinear fashion. A wide range of disciplines, including economics and operations research, takes the view that the relationship between production-input and production-output should be understood as nonlinear.

Both the slack resource and the production theories emphasize that the performance effect of resource allocation is dynamic and complex, and that it deviates from the simple, stable linear trajectory. A small difference in resource-input can bring about a large difference in output, which defies the conventional proportionality assumption embraced by the linear approach. As nonlinear theorizing suggests, the relationship between TTF and performance can be viewed as an unstable equilibrium in which small changes in TTF (input) do not necessarily lead to correspondingly small variations in performance. Therefore, unlike most previous research, this study investigates the effects of TTF on performance based on a nonlinear framework.

In addition to these resource-allocation theories, the nonlinear framework has recently been applied to understanding the nonuniform effects of TAM constructs (such as perceived usefulness (PU) and perceived ease of use (PEOU)) on the behavioral intention (BI) to use IT. For example, Chan and Teo (2007) demonstrate that the BI to use IT changes nonlinearly in response to variations in the values of PU and PEOU. The authors also show that the location of each factor in a PU-PEOU space plays an important role in moderating the impact of PU and PEOU on BI. They postulate that one of the main causes for the inconsistent findings of TAM studies is that researchers have assumed that PU and PEOU, regardless of their values, have the same effects on BI. Therefore, the nonlinear interaction effect of the TAM factors and their locations in the PU and PEOU space should be taken into account in order to gain a better understanding of the meaning and relative significance of PU and PEOU.

The present study also posits that different degrees of fit will have varying effects on performance. Previous studies, including that of Goodhue and Thompson (1995), have generally viewed all fits as identical, regardless of where and when the fit equilibrium was established. In this respect, TTF can be thought of as a single, stable, and static point. However, we propose an alternative view that many points of equilibrium can exist that differ in terms of magnitude and location, each of which has different performance implications. Multiple TTFs occur, particularly when the atomistic approach is adopted. Unlike other mechanisms (e.g., molar or molecular), the atomistic approach conceptualizes and measures the two elements (e.g., task, technology) separately by identifying the location and magnitude of multiple TTF points. This is the approach adopted in this study. We investigate whether TTF at the high end of the equilibrium results in a higher level of perceived IS use and superior IT-driven task performance than TTF at the low end of the equilibrium.

Finally, we employ a three-dimensional modeling approach in order to provide a detailed schematic representation of the nonlinear patterns and the multiple fit states surrounding TTF. As Edwards (1994) notes, many fit studies have suffered as a result of leveraging the two-dimensional approach:

> *The vast majority of these studies [studies on fit] have operationalized congruence by collapsing two or more measures into a single index. […] Unfortunately, these indices present numerous substantive and methodological problems that severely threaten the interpretability and conclusiveness of the obtained results* (Edwards, 1994, p. 51).

To redress this issue, we instituted a three-dimensional response surface method (RSM), which preserves the value of each variable (e.g., task and technology) and precisely computes the extent of fit without collapsing the variables into one. This method successfully accords with the purpose of the atomistic approach in evaluating the fit between two constructs and investigating its impact on other variables.

The specific research questions addressed in this study are as follows:

- Is the nonlinear approach suitable for explaining the effects of TTF on performance? To what extent do nonlinear conceptualization and validation account for the dynamics between TTF and performance?

- Does TTF at varying levels of IT demand and supply in terms of IT features and functions lead to different levels of perceived IS use and task performance? More specifically, is the TTF that occurs at equilibrium with a high IT demand and supply superior to the TTF at equilibrium with low levels of IT demand and supply?

2. Literature Survey

Over the past two decades, the TTF framework has spawned a wealth of research and theorizing in the IS field (e.g., Belanger, Collins, & Cheney, 2001; D'Ambra & Wilson, 2004; Dennis et al., 2001; Dishaw & Strong, 1998; Goodhue & Thompson, 1995; Nance & Straub, 1996; Tan, Teo, & Benbasat, 2010; Zigurs & Buckland, 1998; Zigurs & Khazanchi, 2008). Goodhue and Thompson (1995) define TTF as a situation in which "a technology provides the features and support that fit the requirements of a task" (p. 214). The TTF literature suggests that technologies produce and provide the information necessary for completing tasks, facilitating their task activities and processes, and assisting users with making optimal decisions, all of which positively influence performance. By integrating TTF into the IS utilization framework, Goodhue and Thompson (1995) demonstrate that IT, when utilized optimally in support of a task, can significantly improve task performance. Furthermore, Goodhue (1995) argues that TTF can be used as a surrogate measure of perceived IS success, and establishes specific items for measuring TTF.

Since Goodhue and Thompson's (1995) pioneering work, a plethora of conceptualizations and empirical instruments have been proposed surrounding TTF (see Table 1). Zigurs and Khazanchi (2008) identify several theoretical frameworks to provide the conceptual basis for understanding the nature and dynamics of fit in relation to IT: media richness theory, channel expansion theory, adaptive structuration theory, task technology fit, and the fit appropriation model. Some theories define fit as an outcome of contingency, while others treat it as an emergent process of structuration or a key operating element of an ideal profile (Zigurs & Khazanchi, 2008). Among these diverse conceptualizations, studies grounded in the TTF framework have typically focused on IT characteristics and individual or group task characteristics (e.g., Dennis et al., 2001; Zigurs & Buckland, 1998). IT characteristics can be further refined into presentation mode and processing tools (e.g., Vessey & Galletta, 1991). Recently, a study based on resource matching theory in accordance with the spirit of TTF stated that "if a decision aid facilitates the match between the cognitive resources available and those required for the decision task, decision performance should improve" (Tan et al., 2010, p. 321).

Typically, the molecular and the molar approaches have been used to test TTF empirically, while the atomistic mechanism has rarely been adopted in the IS field (see the last column in Table 1). The atomistic approach independently evaluates two predictor variables (e.g., task and technology) and synthesizes them in some quantitative manner (e.g., computation) in order to characterize and operationalize the focal concept of TTF effectively. The molecular approach, on the other hand, directly gauges the perceived discrepancy between the two constructs, such as whether the supply of technology exceeds or falls short of what the individual needs to complete a task. Similarly, the molar approach measures the perceived fit, match, or similarity between two predictors. The key difference between the molecular and molar mechanisms is that the former determines subjective discrepancies and preserves the direction of their differences, whereas the latter merely attends to the perception of fit and disregards the direction of their differences, thereby treating positive and negative discrepancies as equivalent in terms of misfit.

Table 1. Studies of Task-Technology Fit (TTF)

Authors	Data source, data type	Operationalization of TTF	Task-technology fit	Analytical approaches*
Vessey & Galletta (1991)	Experiment	Computed	Cognitive fit as the match between task, problem representation (e.g., mode of presentation of data) and individual problem solving skills	1. Molecular approach 2. Covariation 3.Linear approach
Goodhue & Thompson (1995)	Survey	User evaluation	Data quality Locatability of data Authorization to access data Data compatibility between systems Training and ease of use Production timeliness Systems reliability IS relationship with users	1. Molar approach 2. Moderation 3. Linear approach
Nance & Straub (1996)	Field research with survey	Computed	Effort to use, which assesses learning required to utilize IT for certain types of data processing tasks	1. Molecular approach 2. Matching 3. Linear approach
Dishaw & Strong (1998)	Survey	Computed	Interaction of task and technology characteristics: Production fit Coordination fit	1. Molecular approach 2. Moderation 3. Linear approach
Zigurs & Buckland (1998)	Theoretical paper	Computed	Ideal profiles: viable alignments of task and technology	1. Molecular approach 2. Profile deviation 3. Linear approach
Shirani, Affisco, & Tafti (1999)	Experiment	User evaluation	Interaction of task and technology	1. Molar approach 2. Moderation 3. Linear approach
Belanger et al. (2001)	Field research with survey	User evaluation	Interaction of between technology variables	1. Molar approach 2. Moderation 3. Linear approach
Dennis et al.(2001)	Meta-analysis	N.A.	Three ideal profiles	1. Molecular approach 2. Profile deviation 3. Linear approach
Dishaw & Strong (2003)	Survey	Computed	Interaction of task and technology characteristics	1. Molecular approach 2. Moderation 3. Linear approach
D'Ambra & Wilson (2004)	Survey	User evaluation	Information resource Fun Mediation Use control	1. Molar approach 2. Moderation 3. Linear approach

Table 1. Studies of Task-Technology Fit (TTF) (cont.)

Authors	Data source, data type	Operationalization of TTF	Task-technology fit	Analytical approaches*
Staples & Seddon (2004)	Survey	User evaluation	Work compatibility Ease of use Ease of learning Information quality	1. Molar approach 2. Moderation 3. Linear approach
Majchrzak et al. (2005)	Survey	Computed	Interaction of IT support for contextualization and task nonroutineness	1. Molecular approach 2. Moderation 3. Linear approach
Strong, Bandy, & Dishaw (2006)	Survey	Computed	Interaction of task and technology characteristics	1. Molecular approach 2. Moderation 3. Linear approach
Zigurs & Khazanchi (2008)	Conceptual paper	N.A.	Patterns which are representations of specific management and team member practices that contribute to the effectiveness or ineffectiveness of virtual teams	Holistic approach, Not amenable to statistical analysis
Tan et al.(2010)	Experiment	Computed	Interaction of the specific decision support and the product attribute load	1. Molecular approach 2. Moderation 3. Linear approach

*(1) Edwards, Cable, Lambert, Shipp, and Williamson's (2006) classification; (2) Venkatraman's (1989) classification; and (3) linear or nonlinear approach.

TTF studies using the molecular or molar fit approaches explicitly ask the respondents to determine the degree of fit. Goodhue (1998), for example, divided the task domain of IT-supported decision-making into several components: identification, access, and interpretation of data for decision-making. He then developed 26 measurement items addressing the 12 dimensions of TTF. Goodhue (1998) asked users to evaluate the current degree of TTF directly according to these constructed survey items.

Despite several advantages (e.g., simplicity, ease, and low cost of data collection), both the molecular and molar approaches are subject to the following limitations. According to Edwards (1991), these methodological approaches cannot successfully evaluate the respective influences of task and technology on performance variables (e.g., IS use and performance), nor can they precisely capture the dynamic, multiple effects of TTF at different levels of demand and supply. Moreover, the direct mechanisms of the molecular and molar approaches make it difficult to validate the significance of systematic differences between TTF and TT-misfit on dependent variables. Second, when direct measures are applied in conjunction with measures of other work-related attitudes, a structural bias may result that consistently confound the results (Kristof, 1996).

Analytical methods employed to examine TTF include linear regression, partial least square regression, path analysis, factor analysis, and focus group interviews with content analysis. The vast majority of TTF studies presume a linear association between TTF and performance. Furthermore, most IS studies measure TTF directly based on user perception, and analyze it by aggregating two or more component factors into a composite index. Some studies (e.g., Belanger et al., 2001; D'Ambra & Wilson, 2004; Goodhue & Thompson, 1995; Shirani et al., 1999), including

Goodhue (1998), operationalize TTF as a user evaluation across comprehensive domains, while other studies measure TTF as the computed deviation from an ideal profile (e.g., Dennis et al., 2001; Zigurs & Buckland, 1998).

In summary, despite their noticeable progress, TTF studies in the IS field have several structural limitations. A refined conceptualization and analytical approach is required through which a more systematic and holistic understanding of the fit between task and technology can be established. The present study attempts to reach this understanding. Findings in the literature are extended by enhancing conceptual and methodological insights into the relationship between task and technology. A nonlinear approach is used to investigate the effects of TTF on task performance, and a methodological trajectory is employed that preserves the independence of the two underlying predictor variables (task and technology).

3. Hypotheses Development

3.1. *TTF Effects on Perceived IS Use and Task Performance*

According to the complementary perspective of fit (Edwards, 2008), TTF can be understood as a form of “needs-supplies” fit because it refers to “the degree to which a technology assists an individual in performing his or her portfolio of tasks” (Goodhue & Thompson, 1995, p. 216). TTF studies are motivated by recognizing technology as necessary to perform tasks effectively. TTF researchers evaluate how well the need for technology is met by the technology supply of an organization. In this study, we conceptualize TTF as the state of equilibrium between individual employees’ demand for a number of technological functions with a wide range of applications (e.g., communication, documentation, and administrative applications) and the supply of such resources. Therefore, IT represents artifacts and trajectories that help individuals to fulfill requirements and meet goals.

In the framework of complementary TTF, “IT deficiency” refers to a situation in which the supply of IT functions for a given application (e.g., communication, documentation, or workflow management) is below the level users require to perform tasks successfully, whereas “IT surplus” denotes an excess of IT functions. Both situations represent a state of misfit. An insufficient supply of IT functions has a detrimental effect on task productivity (see Higa, Sheng, Shin, & Figeuredo, 2000; Oh & Pinsonneault, 2007), but the effects of IT surplus have received considerably less attention (i.e., they’ve been studied only through case-based anecdotes). Ahituv and Greenstein note that “sometimes it is better to invest less [in IT] in order to achieve more” (2005, p. 519), which suggests that an IT surplus may decrease task productivity. For example, when a system has an excess of features, both accessibility of information and processing performance may deteriorate (Jarvenpaa, 1989).

Studies of industrial design have cautioned IT developers to avoid the temptations of creeping featurism and the worship of complexity (Norman, 2002). Norman’s (2002) guidelines for ideal designs emphasize the need for features such as visibility, affordability, constraints, and natural mapping, all of which are concerned with simplifying functions. The technology paradox is that “the same technology that simplifies life by providing more functions in each device also complicates life by making the device harder to learn, harder to use” (Norman, 2002, p.31). An excess of IT functions can increase users’ confusion and distraction, induce resistance, and ultimately lead to abandonment, all of which negatively affect the use of IT (Thompson, Hamilton, & Rust 2005). Chin, Marcolin, and Newsted (2003) suggest that an inordinate number of features (albeit potentially useful) can be psychologically overwhelming and negatively affect motivation to use IT (e.g., hedonic motivation).

Furthermore, high-tech marketing studies indicate that customers do not necessarily welcome an inordinate number of innovative functions in high-tech products. Moore (2002) cautiones against multitudinous functions, and contendes that success in the mass market is more likely when the number of technical functions is limited. He discusses the characteristics of each phase in the technology adoption lifecycle, particularly the chasm between early adopters (i.e., visionaries who favor radical and innovative functions for the sake of organizational competitiveness) and early majorities (i.e., pragmatists who prefer incremental improvements on existing operations). The IS literature also voices concern over an excess supply of IT features. Jasperson, Carter, and Zmud (2005) state that:

> *A simple increase in the number of features used may not necessarily correlate with an increase in performance outcomes. Individuals can apply features in non-productive ways or they may be overwhelmed by the presence of too many features, resulting in an inability to choose among feature sets or to apply the features effectively in their work* (pp. 530 -531).

Consequently, both a shortage and an excess of IT functions reduces IT use and degrades task performance. Therefore, we posit that:

> **H1:** *The worse the fit between task and technology, the less IS will be used. The better the fit between task and technology, the more IS will be used.*

> **H2:** *The worse the fit between task and technology, the worse the task performance will be. The better the fit between task and technology, the better the task performance will be.*

3.1.1. TTF Location and Differential Performance

Keil, Beranek, & Konsynski (1995) propose a four-quadrant analysis in order to provide a finer level of granularity regarding the relationship between TAM constructs (e.g., PU and PEOU) and their relative importance to IT use. More specifically, these scholars divide the dimensions of PU and PEOU into high and low categories to produce four combinations in a 2 X 2 grid. Quadrant 1 represents systems that show low PU and low PEOU, while quadrant 4 includes systems that exhibit high PU and high PEOU (Keil et al., 1995, p. 9). With systems that exhibit the high/low combination of the two constructs, Quadrants 2 and 3 fall into sections between these two extremes. Keil et al. (1995) articulate that the location of each construct in the grid determines its effectiveness, and empirically demonstrate that Quadrant 4 outperforms the other quadrants with regard to IT use.

Based on a two-dimensional PU-PEOU space, Chan and Teo (2007) extende and further refine Keil et al.'s classification by investigating how each of the 49 PU-PEOU combinations derived from the seven-point Likert scales was associated with performance (e.g., BI). The key findings of their study suggest that the effects of TAM constructs are not uniform and symmetric over the PU-PEOU space, and the importance of PU and PEOU varies depending on their spatial locations.

Building on these previous findings, we posit that the effects of TTF on perceived IS use and task performance are not identical across different levels of TTF. More specifically, TTF with equilibrium between a large IT demand and a large IT supply is expected to be superior to TTF with equilibrium between a small IT demand and a small IT supply. According to Au, Ngai, and Cheng (2008), fulfillment of needs is one of the primary factors leading to satisfaction for IS users, which, in turn, determines their level of IS use. Regardless of the objectives of IS use (i.e., social relations, work performance, or self-development), user satisfaction and fulfillment of user needs are positively correlated (Au et al., 2008).

Several IS studies (e.g., Burton-Jones & Straub, 2006; Igbaria & Tan, 1997) have investigated the extent to which systems are used to carry out tasks. These studies focus on the dyadic relationship between task and technology, and employ two underlying metrics to measure computer use: the number of tasks involving the use of computers and the number of applications. Huang and Wei (2002) found that IS use had a positive impact on individual performance as reflected by improved decision-making quality, performance, productivity, and effectiveness. Consequently, these studies suggest that the more a user's IS function needs are fulfilled during task execution, the greater the levels of satisfaction and IS use will be, and thus, the better the individual performance. Goodhue and Thompson (1995) assert that high TTF increases the performance impact of the system. This study also investigates the performance impact of the system (not the generic task performance independent of computer systems). We argue that this impact can vary according to different levels of TTF.

IT needs evolve over time depending on the amount of user experience. Jasperson et al. (2005) contend that under-utilizing an ERP system's functions impedes fully realizing the system's expected value. This problem can be overcome by users' post-adoptive behavior. Based on a feature-centric view of technology, Jasperson et al. assert that, as users accumulate experience with a system, they begin to incorporate it more and more into their work, and utilize more of the technology's features to perform their tasks. Consequently, users eventually learn to use the system to its full potential and capacity. In this respect, depending on an individual's abilities at the adoption stage, the degree of fit between task and technology might evolve over time from initial acceptance to routine use (Saga & Zmud, 1994), to extended and in-depth utilization (Schwarz, 2003), and finally to emergent (Saga & Zmud, 1994) and innovative use (Agarwal, 2000). Consequently, the degree to which a user’s needs are met and the stage at which users adopte the system determine the level of TTF, which, in turn, affects IS use and task performance. Therefore, we propose that:

H3: *TTF with equilibrium between high IT demand and high IT supply leads to more IS use than TTF with equilibrium between low IT demand and low IT supply.*

H4: *TTF with equilibrium between high IT demand and high IT supply leads to superior task performance than TTF with equilibrium between low IT demand and low IT supply.*

4. Research Methodology

4.1. Data

Data were collected from the electronic data processing systems department of a large, national bank in Korea. This company implemented groupware systems to facilitate a diverse menu of activities, including team communication, schedule management, and posterior audits of IT staff engaged in project management. Table 2 displays some of the system’s key functions. This large-scale system was introduced to the organization several months prior to this study. Therefore, at the start of the study, employees had had sufficient exposure to the system to evaluate its impact on their tasks. To validate our measurement items, we conducted interviews with representative employees of this department at several different instance. Initial measurement instruments were then refined and modified according to their feedback and suggestions.

Data collection, in the form of a survey of all employees, took place over a four-week period from June 2 to June 27, 2005[1]. Prior to distributing the questionnaire, the purpose of the study was explained to each participant in order to ensure a high participation rate. In total, 363 employees expressed interest in participating. The survey was subsequently distributed either in person or via email. One week after initial distribution, we contacted non-respondents via personal visit, email, or telephone to request participation in the study. The final sample included 303 completed questionnaires, which represented an 83.5 percent overall response rate. Of these responses, 74 were invalid and therefore unusable for various reasons. Specifically, 17 replies were excluded because the respondents marked identical scores throughout the entire questionnaire. A large number of incomplete responses disqualified 28 questionnaires. Finally, 29 responses were omitted because the respondents indicated that their use of the groupware was extremely limited[2]. Consequently, the final sample comprised 229 responses.

The sample consisted of 191 males (83.4%) and 38 females (16.6%). Ages ranged from early 20s to late 50s. Respondents in their 30s represented 60 percent (n = 137) of the sample, and those in their 40s comprised 26.1 percent of the sample (n = 60). The majority held bachelor degrees (57.2%). Distribution of job tenure positions across various responsibilities (e.g., floor staff, assistant manager, manager, and general manager) was relatively even. The average lifetime tenure period of the

[1] Survey questionnaire items were originally written in Korean. They were translated into English for journal submission.
[2] These 29 respondents were not regular employees of the bank. They were dispatched from an IS outsourcing consulting company for system maintenance.

respondents was 126 months (10 years and 6 months), while the tenure period in the current IS department varied substantially (ranged from 1 to 20 years).

Table 2. Key Functions Provided by the Groupware System

Function	Descriptions
Group meetings and conferencing	Supporting group meetings in multiple formats, including email, instant messaging, voice-only conferencing, and voice + video + text conferencing
News and bulletin boards	Storing and disseminating of information, such as news and announcements, among project participants
Discussion forum	Sharing of information and ideas for specific predefined groups corresponding to subject or project relevance
Document management	Creating, storing, sharing and retrieving of information/documents in digital archives Enabling synchronized sharing, discussing, and co-editing of documents among project group members
Workflow management and document approval	Automating of work processes by routing information/document to different parties according to a predefined or ad hoc sequence
Schedule management	Scheduling of project work and group meetings and task coordination

4.2. Variables and Measurements

4.2.1. Task and Technology

Ellis, Gibbs, and Rein define groupware as “computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment” (1991, p. 40). With the exception of information processing, collaborative functions (e.g., communication support and task coordination) are available for group activities such as scheduling, communication, approval, and meetings. Tasks include the portfolio of activities performed to achieve predetermined objectives (Withey, Daft, & Cooper, 1983) or to turn inputs into outputs (Goodhue & Thompson, 1995). The tasks chosen for this study were not necessarily associated with group-based decision-making. The survey asked participants to determine how the collaborative IS (groupware) helped them to perform their individual tasks. The IS department of the company in our sample performed two key functions: system development and maintenance. The collaborative technology in our study was designed to support the specific functions illustrated in Table 2.

The task characteristics in our study relate to the amount of IT required to perform various work-related activities. Accordingly, they are measured as the degree to which users require the functions of groupware in order to implement each individual task. In contrast, the technology construct denotes the actual supply of IT that supports the particular task. Six questionnaire items regarding groupware functions were developed for both constructs after the field observations and interviews (see Appendix). Measurements in this study were based on the need and supply of resources because TTF was conceptualized as the equilibrium between an individual employee's need for a number of technological functions with a wide range of applications and the supply of such resources. This is a conventional approach in fit research. For example, Meglino and Ravlin (1998) and Cable and Edwards (2004) adopt a similar approach: they measure the demand and supply of resources based on the same measurement items.

4.2.2. Measurements for TTF

Broadly, we can operationalize the concept of fit in two ways. The first method (molar fit) is to ask users directly to indicate the degree of fit between the factors involved. The second approach (atomistic fit) involves assessing each component independently through a survey instrument, and then computing the fit based on users' responses (see Venkatraman (1989) for the computational aspect of fit).

Although valid and useful, molar fit does not independently assess the individual impact of each independent factor on the dependent variables (Edwards, 1991; Oh & Pinsonneault, 2007). Moreover, when TTF is achieved either with equilibrium between a large amount of IT demand and a large amount of supply or with equilibrium between a relatively smaller amount of each, molar fit cannot easily distinguish the effect of TTF in relation to the dynamic changes in equilibrium levels between IT demand and supply. Finally, measurement of molar fit is limited in its ability to ascertain the varying effects of TTF and TT-misfit on dependent variables. Atomistic fit offers a means of understanding and comparing the effects of multiple types of misfit on individual performance. Kristof (1996) encourages the use of atomistic fit, particularly when the dependent variable in question relates to performance outcomes rather than attitudinal outcomes, because the concept of molar fit closely resembles individual attitudes. To address these issues, while the recommendations of previous studies (e.g., Edwards, 1991; Kristof, 1996) were also followed, the atomistic fit was used as the main measurement scheme in this study.

4.2.3. Perceived IS Use and Task Performance

In this study, IS use refers to individuals' perceived use of groupware to perform their tasks. We derived the three measures of perceived use (period, frequency, and overall dependency) from Davis (1989). These measures reflect the respondents' subjective perceptions about their use of groupware. The perceived IS use construct therefore represents the composite scale derived from the average value of these three measures. Finally, individual performance is defined as users' perceptions of the degree to which using group support systems contributes to improving task execution capability, reducing task load, and decreasing the challenges of actual task execution (Hiltz & Johnson, 1990). As Goodhue and Thompson (1995) do, we can think about task performance as the performance impact of systems on individual tasks. More specifically, task performance as viewed in this study refers not to performance in and of itself, but rather to performance from the system. To measure this construct, Davis (1989), Hiltz and Johnson (1990), and Goodhue and Thompson (1995) asked individuals to self-report on the perceived impact of computer systems and services on their effectiveness, productivity, and overall job performance (Goodhue & Thompson, 1995, p. 223). We adopted the measures used in Hiltz and Johnson (1990) for this construct.

5. Hypothesis Testing and Analysis

5.1. Construct Reliability and Validity

Before testing the hypotheses, we verified whether our measurement items were reliable and valid. All Cronbach's alpha values exceeded the recommended threshold value of 0.7 (Nunnally, 1978; O'Leary-Kelly & Vokurka, 1998). Values were 0.820 for tasks (desired IT level), 0.783 for IT (actual IT level), 0.754 for IS use, and 0.919 for task performance, which suggests that all measures were reliable. To test validity, we adopted the principal component method of factor analysis and rotated the axes using the varimax method. This method was applied to 18 items of four latent variables. As Table 3 shows, all factor loadings on these four factors were higher than 0.5, which supports the convergent validity of the measurement items (Hair, Anderson, Black, & Tatham, 1998).

Table 3. Reliability and Exploratory Factor Analysis

Variables	Factors				Cronbach's alpha
	1	2	3	4	
Task (Desired IT level) 1	**.729**	.071	.203	.088	0.820
Task (Desired IT level) 2	**.729**	.175	.197	.028	
Task (Desired IT level) 3	**.770**	.139	.089	.231	
Task (Desired IT level) 4	**.641**	.153	.117	.243	
Task (Desired IT level) 5	**.506**	.274	-.112	.440	
Task (Desired IT level) 6	**.505**	.303	-.005	.363	
IT (Actual IT level) 1	.410	**.505**	-.023	.353	0.783
IT (Actual IT level) 2	.224	**.525**	.176	.419	
IT (Actual IT level) 3	.253	**.589**	-.048	.242	
IT (Actual IT level) 4	.051	**.608**	.008	.245	
IT (Actual IT level) 5	.146	**.751**	.110	.054	
IT (Actual IT level) 6	.103	**.728**	.255	.041	
IS use 1	.387	.094	**.609**	.410	0.754
IS use 2	.017	.116	**.863**	.082	
IS use 3	.219	.090	**.768**	.095	
Performance 1	.197	.200	.128	**.832**	0.919
Performance 2	.223	.185	.167	**.867**	
Performance 3	.185	.242	.172	**.825**	

Factor extraction: principal component analysis.
Rotation: varimax with Kaiser normalization.
Factor rotation converged after five rounds of repeated calculations.

Tables 4a and 4b present the descriptive statistics and discriminant validity analysis. The analysis demonstrates that all the AVE values for each construct exceeded 0.5 and that each AVE value was greater than the correlation coefficient of its respective construct. Therefore, discriminant validity is satisfactory at the construct level for all constructs.

Table 4a. Descriptive Statistics of Variables and Discriminant validity analysis

Variables	Average	Std. Dev.	Range	Correlation			
				1	2	3	4
1. Task (Desired IT level)	5.510	0.661	3.50	**.661**[a]			
2. IT (Actual IT level)	5.134	0.689	3.33	.569**[b]	**.621**		
3. IS use	5.242	1.344	6.00	.475**	.515**	**.698**	
4. Performance	5.153	1.216	5.00	.550**	.529**	.662**	**.892**

[a] Diagonals: average variance extracted (AVE) from the observed variables by the latent variables
[b] Off-diagonals: construct-level correlation = (shared variance) $^{1/2}$
*p < 0.05; **p < 0.01

Table 4b. Descriptive Statistics of Items

Item level	Average	Standard deviation	Range
Task 1	6.17	.830	4
Task 2	5.57	.849	5
Task 3	5.54	.910	4
Task 4	5.19	1.036	6
Task 5	5.42	.893	4
Task 6	5.17	.937	4
IT 1	5.57	.941	4
IT 2	5.13	.773	4
IT 3	5.03	.982	5
IT 4	4.58	1.063	6
IT 5	5.38	1.072	5
IT 6	5.11	1.106	5
IS use 1	5.90	1.125	6
IS use 2	4.68	1.564	6
IS use 3	5.61	1.557	6
Performance 1	5.13	1.064	5
Performance 2	5.05	1.109	5
Performance 3	5.03	1.084	5

5.2. Results

5.2.1. Polynomial Regression Method

To test the hypotheses, we adopted the polynomial regression that Edwards (1993) proposes. This approach models the relationship between two independent variables (task characteristics and IT characteristics) and the dependent variable (IS use and task performance) as a non-linear function.

Moreover, this regression mechanism leverages response surface methodology (RSM) (Box & Draper, 1987; Khuri & Cornell, 1987) to demonstrate the joint effects of the independent variables on the dependent variables on a three-dimensional surface. RSM allows the analysis of various features of the three-dimensional surfaces corresponding to a quadratic equation, such as the slope over the principal axes (the first principal axis, the second principal axis, Y=X, Y= -X), and the curvature of the surface. The slope over the axis indicates the increased rate of the dependent variable along the axis, while the curvature indicates whether the surface of the quadratic equation is convex or concave along the axis.

One major advantage of this mechanism over the traditional method (e.g., two-dimensional analysis) is its ability to capture the dynamic interplay between the various constructs with no artificial treatment (Edwards, 1994). Traditional methods, which collapse the indices representing two independent variables into a single index, have inherent limitations when examining their respective effects on the dependent variable. Edwards (1994) suggests that such “artificial manipulations” (e.g., reducing the three dimensions into two) could result in numerous substantive and methodological problems, and so hinder the interpretability and conclusiveness of the obtained results. For example, using the difference-score mechanism for survey data (e.g., a 7-point Likert scale) means that only the computed value (say, 3) from two independent variables is input into the analysis without reference to how it was derived. Many possible combinations exist for this particular computed value of 3, such as (4 - 1), (5 - 2), (6 - 3), and (7 - 4), but the two-dimensional approach treats all these possibilities identically.

In contrast, polynomial regression can identify the effect of each independent variable on the dependent variable separately. Moreover, the polynomial mechanism can detect the possible quadratic effects and the interaction effect between the independent variables involved. The quadratic equation (e.g., $(X-Y)^2$) in the polynomial regression combined with RSM can provide more-fruitful and dynamic insight into the relationship between TTF and the dependent variables (perceived IS use and task performance) on a three-dimensional surface (Edwards, 1994).

The polynomial regression method is based on three assumptions. First, the component measures should be commensurate, which means that they express the components in terms of the same content dimension. Examples of commensurate measures include actual and desired challenge, expected and received pay, and supervisor and subordinate reports of performance. Second, it is assumed that the component measures use the same numeric scale. Scale equivalence is required to determine the degree of correspondence between the component measures and compare coefficient estimates. Third, like any application of regression analysis, it is assumed that all measures are at the interval or ratio level (Edwards, 2002). In this study, our measures include the desired requirement of IT (task) and the supply of IT (technology). All measures are based on the 7-point Likert scale. Therefore, the assumptions of polynomial regression approach were satisfied.

For the polynomial regression and multivariate regression analyses, we used SYSTAT Version 11.0 and SPSS Version 17.0, respectively. RSM analysis was conducted using SYSTAT Version 11.0. Following the suggestion of Lance (1988) and Edwards and Parry (1993), we centered the variables at a middle point (i.e., 4 on the 7-point scale) prior to analysis. This methodological enrichment was carried out in order to reduce the possibility of multi-collinearity and to allow accurate interpretation of the three-dimensional graph. The centering method is highly effective for addressing potential multicollinearity between the main and interaction effects when estimating the coefficients in the full model (Bottomley & Doyle, 1996; Lance, 1988).

5.2.2. Hypothesis Testing

The quadratic equation employed in this study included task characteristics (X), technology characteristics (Y), quadratic terms for each independent variable (X^2, Y^2), and an interaction term between the two independent variables (X*Y). In other words, the TTF and the outcomes (Z) were represented in terms of polynomial regression as follows:

$$Z = b_0 + b_1X + b_2Y + b_3X^2 + b_4XY + b_5Y^2 + e \quad (1),$$

where X = task characteristics, Y = technology characteristics, and Z = perceived IS use or task performance after IS implementation.

Table 5 shows the results of testing the quadratic model's validity compared to the linear equation. As Table 5 shows, a comparison of models 1 and 2 demonstrated that model 2 (the quadratic model) explained more of the variance in perceived IS use and performance than model 1. The adjusted r-square for model 2 was significantly greater than that for model 1 at the 90 percent confidence level. This result suggests that the quadratic model can be more useful for understanding the relationship between TTF and the dependent variables than the linear model. Table 5 also shows five β coefficients (as in Equation 1 above). These coefficients depict the response surface and allow analysis of the slopes and curvatures of this graphic surface.

Table 5. Validity of Second Order Polynomial Regression Analysis

Variables	IS use		Task performance	
	Model 1	Model 2	Model 1	Model 2
Constant (b_0)	3.617** (19.329)	3.307** (12.785)	3.492** (21.533)	3.349** (14.820)
Task (b_1X)	.546** (4.007)	1.086** (2.734)	.677** (5.733)	.970** (2.794)
IT (b_2Y)	.706** (5.404)	1.098** (2.674)	.564** (4.982)	.787* (2.194)
$Task^2$ (b_3X^2)		-.369* (-2.071)		-.258+ (-1.657)
Task*IT (b_4XY)		.465+ (1.721)		.414+ (1.754)
IT^2 (b_5Y^2)		-.492** (-2.758)		-.381* (-2.443)
R^2 Adjusted R^2 F	.314 .308 51.700**	.347 .332 23.711**	.371 .366 66.702**	.392 .378 28.710**

Numbers in parentheses indicate t-values. +p<0.1, *p<0.05, **p<0.01

Hypotheses 1 and 2 predict that the outcomes would be at the highest level along the line X=Y, where the amount of IT required by a task is equivalent to the amount of technology provided. Testing these hypotheses requires two stages of analysis. In the first stage, the first principal axis should run along the Y=X line (Edwards, 2002). For the concave surface, the downward curvature is smallest along the first principal axis. If the first principal axis is not significantly different from the Y = X line, the congruence between task and technology (i.e., Y = X) leads to the highest level of outcome. In the second stage, the downward curvature should be significant along the *Y = -X* line (i.e., it should run perpendicular to the Y = X line) (Edwards, 2002). For the concave surface, the significant downward curvature along the Y = -X line denotes that outcomes are maximized at the point of perfect fit and decrease in either direction. Table 6 summarizes the key features of each surface as theyrelate to our hypotheses.

To show that the first principal axis does not differ from the Y = X line in the first stage, a comprehensive validation process is necessary. This process determines whether the slope of the first principal axis (P_{11}) differs from 1, and whether the point at which the first principal line intersects the Y = -X line ($-P_{10}/(1+P_{11})$) differs from zero, where P_{10} and P_{11} represent the intercept and the slope of the first principal axis, respectively. If the slope of the first principal axis differs from 1, the axis rotates from the Y = X line. Further, if the intercept of the first principal axis differs from zero, that axis will shift laterally (Edwards & Harrison, 1993; Edwards & Parry, 1993; Edwards, 2002).

Table 6. Response Surface Analysis

		IS use	Performance	Tested hypothesis
Stationary point	X_0	3.097 (0.019)	4.802 (0.028)	
	Y_0	2.579 (0.025)	3.642 (0.036)	
First principal axis	P_{10}	0.195 (0.009)	0.059 (0.037)	
	P_{11}	0.770 (0.098)	0.746 (1.289)	
	$-P_{10}/(1+P_{11})$	-0.110 (-0.064)	-0.034 (-0.021)	
Y = X	Slope (b_1+b_2)	2.184** (3.773)	1.757** (4.850)	Hypothesis 3 and hypothesis 4
	Curvature ($b_3+b_4+b_5$)	–0.396 (-1.815)	-0.225 (-1.613)	
Y = -X	Slope (b_1-b_2)	-0.011 (-0.020)	0.183 (0.377)	Hypothesis 1 and hypothesis 2
	Curvature ($b_3-b_4+b_5$)	-1.326** (-2.977)	-1.053** (-2.795)	

Numbers in parentheses indicate t-values.

$$p_{11} = \frac{b_5 - b_3 + \sqrt{(b_3 - b_5)^2 + b_4^{\,2}}}{b_4} \qquad p_{10} = Y_0 - p_{11} X_0$$

Significance testing was based on 10,000 bootstrap samples.
*p<0.05, **p<0.01

As Table 6 shows, for IS use, the stationary point at which the slope of the surface is zero in all directions is X_0 = 3.097, Y_0 = 2.579. The first principal axis was close to the Y=X line, which P_{11}= 0.770 and $-P_{10}/(1+P_{11})$ = -0.110 indicates. The tests that immediately followed examined whether these values differed significantly from 1 and 0. A bootstrap analysis was conducted 10,000 times as recommended by Edwards (2002). The coefficients and t-values from these bootstrap samples indicated no significant difference of the values of P_{11} and $-P_{10}/(1+P_{11})$ from 1 and 0, respectively (t = 0.098, -0.064, α=0.05). Therefore, the first principal axis for IS use was not significantly different from the Y=X line. This finding suggests that perfect congruence points between task and technology lead to maximal IS use. For task performance, the stationary point was X_0 = 4.802 and Y_0 = 3.642. P_{11} = 0.746 (t=1.289, α=0.05) and $-P_{10}/(1+P_{11})$ = -0.034 (t= -0.021, α=0.05) did not significantly differ from 1 and 0, respectively. These results indicate that task performance is also maximized along the perfectly congruent line between task and technology (Y = X).

As for the second stage, the curvatures of Y = -X were -1.326 for IS use (t= -2.977) and -1.053 for performance (t= -2.795), both of which were significant at the 95 percent confidence level (α=0.05). As hypothesized, the surface of Y = -X was significantly concave, which indicates that the surface has significant downward curvature along the Y = -X line. The results from the above two stages of analysis collectively lend strong support to hypotheses 1 and 2. Figures 1 and 2, representing the response surface, exhibit that the three-dimensional graphs are all concave, and the curvatures extend downward along the Y=X line. These figures suggest that both IS use and task performance increase with increasing balance between task and technology.

Hypotheses 3 and 4, which pertain to changes in IS use and performance along the demand-supply level of fit, were tested using the slope of Y = X. If this slope is significantly positive, outcomes are more likely to increase because the two independent variables then fit more closely at a higher level.

The slopes of the Y = X lines were 2.184 for IS use (t=3.773, α=0.05) and 1.757 for performance (t=4.850, α=0.05). Both were found to be positive and significant. As Figures 1 and 2 show, IS use and performance increased as both X and Y increased with a concave shape. Thus, IS use and performance were higher when both task (demand) and technology (supply) were high than when both factors were low. Therefore, hypotheses 3 and 4 were both supported. In addition, the curvatures of the Y=X line display the changing patterns of IS use and performance along the Y=X line. However, the curvatures of the Y = X line were not significantly changed for either IS use or performance (-0.396, t= -1.815, α=0.05 and -0.225, t= -1.613, α=0.05, respectively). This result suggests that the outcomes show a linear increase as X and Y increase. Thus, IS use and task performance both increase linearly to the maximum value as X and Y increase.

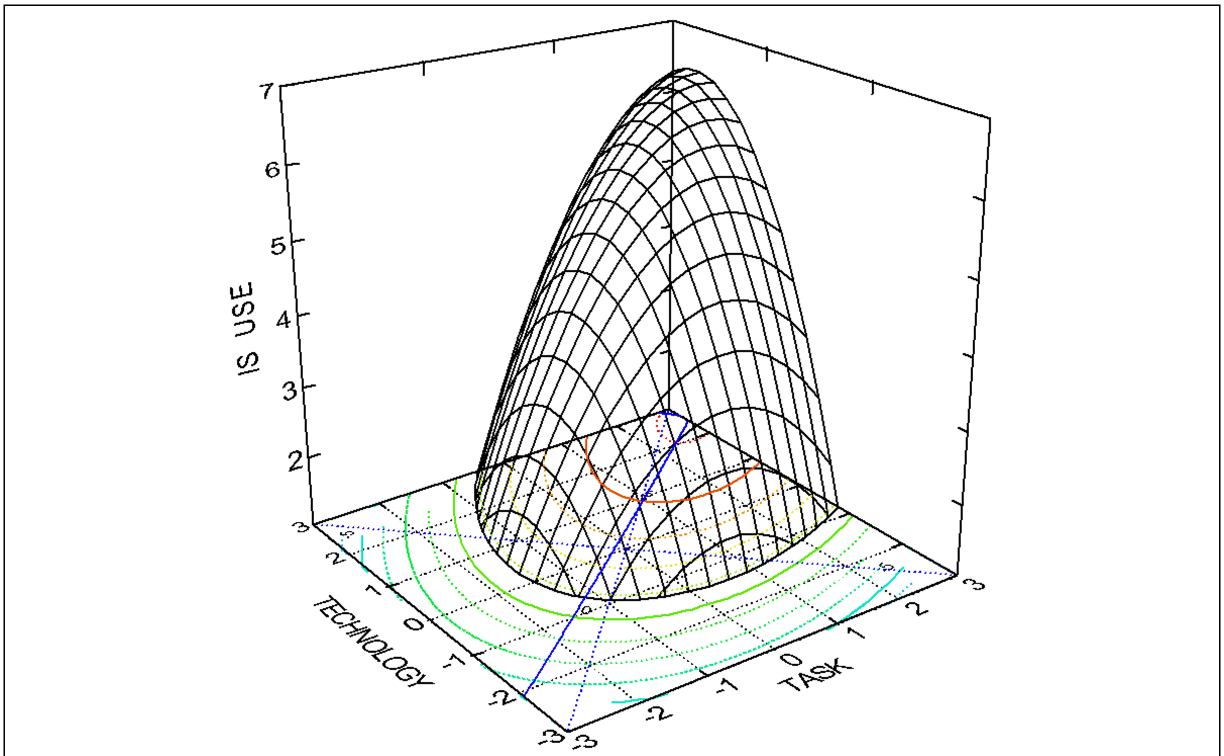

Figure 1. Response Surface Graph of TTF and IS use

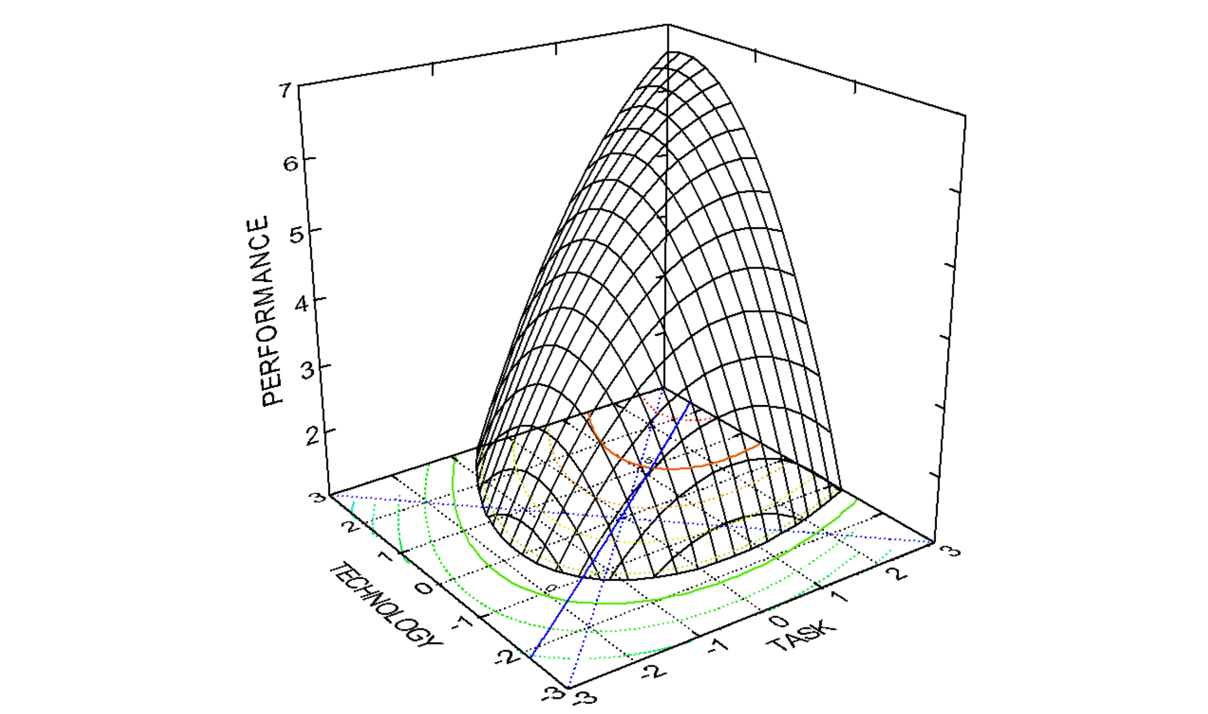

Figure 2. Response Surface Graph of TTF and Performance

5.2.3.The analysis of Under- and Over-supplies of IT

To gain additional insight into the results obtained from the quadratic model, we performed cubical polynomial analyses. These mechanisms are particularly well suited to investigate the symmetry of the effects of misfit with respect to performance. Many prior studies have conventionally assumed that, ceteris paribus, one "unit" of resource shortage (under-supply) is as detrimental to outcome as the same unit of resource excess (over-supply). However, no systematic investigations have been undertaken to validate these assumptions. Regarding the analytical tools, neither the linear models nor the quadratic models are capable of systematically differentiating under-supply from over-supply of IT functions with respect to performance variation. In contrast, a higher-order term included in a cubic polynomial model is able to assess the asymmetrical economic consequences (Chen, Hexter, & Hu, 1993), such as in Equation 2:

$$Z_i = \beta_0 + \beta_1(X_i - Y_i) + \beta_2(X_i - Y_i)^2 + \beta_3(X_i - Y_i)^3 + \varepsilon \quad (2),$$

where X = task characteristics, Y = technology characteristics, Z1 = Perceived IS use and Z2= task performance.

In order to implement the cubic model in Equation 2, we used ORIGIN[3], a popular analytical software package for scientific graphing and data analysis. The Z1 line in Figure 3 shows the differential impact of under-supply (to the right of 0) and over-supply (to the left of 0) on perceived IS use. The curve depicted on the over-supply side is flat, which indicates that the difference in the magnitude of misfit is not substantially associated with task performance. A similar pattern was observed for the under-supply side up to a certain point (i.e., +1.0). However, as the amount of under-supply passes a critical threshold point, the curve on the under-supply side exhibits an exponential decrease for IS use. This result suggests that individuals are discouraged from using IT when the level of IT supply is well below their expectations and needs. With respect to task performance, the cubical analysis shows no

[3] http://www.originlab.com/index.aspx?s=8&lm=218&pid=1561

significant difference between under- and over-supply of IT functions (see the Z2 line in Figure 3). Within a certain range (i.e., between -1.5 and +1.5), task performance is insensitive to the magnitude and direction of misfit, regardless of the under- or over-supply of IT function. However, task performance begins to decrease sharply when the under-supply passes a certain threshold point (i.e., +1.5), although the magnitude of performance erosion is not as substantial as in the case of IS use.

6. Discussion

6.1. Implication for Theory

Based on nonlinear conceptualization and validation, this study investigated several issues relating to the effects of TTF on performance: 1) the suitability of a nonlinear approach for examining the effects of TTF, 2) the cause-and-effect relationships among TTF, perceived IS use, and task performance, and 3) the superiority of TTF with high-end equilibrium on the contour (i.e., high IT demand and high IT supply) over TTF with low-end equilibrium (i.e., low IT demand and low IT supply) for perceived IS use and task performance. We found empirical evidence that validates the hypotheses surrounding these issues. This study contributes to TTF research in several ways. First, the notion of fit was conceptualized and operationalized through a nonlinearity lens, and the impact of TTF on perceived IS use and task performance was investigated from the demand-supply equilibrium perspective. Drawing on the slack resource theory and the production theory, the effects of TTF were theorized as the outcome of resource allocation. Unlike linear models, which tend to capture simple, average, regular ,and tractable behaviors (Anderson, Meyer, Eisenhardt, Carley, & Pettigrew, 1999), nonlinear mechanisms provide more-dynamic and complex insights into the effectiveness of TTF. Furthermore, the nonlinear theoretical and methodological approach offers different vantage points from which to understand how the quantity of IT functions and features determines the level of IS use and affects the task performances of individual employees.

Second, in contrast to previous studies that utilized molecular or molar mechanisms, we adopted the atomistic approach, which allows TTF to be evaluated by articulating and measuring each construct separately, thereby enhancing our understanding of the nature, process, and source of fit. The conceptual link between the two underlying constructs was also clarified. The combination of nonlinear and atomistic approaches can offer strong theoretical and methodological foundations for future TTF research.

Third, our study provides a more-structured understanding of the asymmetric effects of TTF factors on task performance and IS use. To a large extent, our framework extends the nonlinear approach embraced by Chan and Teo (2007), who evaluated the asymmetric and nonuniform effects of TAM constructs (e.g., PU and PEOU) on the BI to use IT. In contrast to typical assumptions made by TAM studies, Chan and Teo’s (2007) key findings suggest that the value of the BI changes nonlinearly in the PU-PEOU space and that the location of TAM constructs in the space determines their impacts on BI. Like these approaches and findings, our framework offers a systematic mechanism through which to understand the differential performance implication of TTF factors in a three-dimensional space. The three-dimensional RSM employed in this study offers researchers more-detailed and finer spatial observations about TTF by facilitating analysis of the asymmetric, differential impacts of the numerous task and technology combinations on perceived IS use and task performance. The non-linear approach and the cubic analyses provided valuable insight into the complex relationships involved in IT, individual performance, and IS use in the three dimensional task-technology-performance space.

6.2. Implication for Practice

In addition to its research-related contributions, this study offeres prescriptive guidance for IS managers regarding how IS use and individual performance can be enhanced through effective management of IT-related resources. Our findings suggest that TTF plays an important role in stimulating individuals to effectively use IT and successfully perform their tasks. Interestingly, the results suggest that users tend to welcome IS (e.g., groupware) only to the extent that they require its functions and features when executing tasks. This suggests that IS designers and managers must pay increased attention to the quantity aspects of user requirements, and should offer the specific number of functions that users require. For various reasons (e.g., lack of communication with users, overestimations of user requirements), IS developers are tempted to include an excess of technical functions beyond what is required and expected by users.

Many IS managers are "trapped" by the idea that more is better when dealing with the number of IT functions and features in IT systems. This study’s findings suggest that an excess of IT functions could be as detrimental for IS use and task performance as a lack of functionality. Because higher physical costs are necessary to develop more IT functions than to develop fewer IT functions, and the costs associated with development are irrecoverable, an over-supply of IT functions is economically undesirable. However, as demonstrated in the cubic analysis, a substantial under-supply of IT functions can also significantly discourage employees from IT use, which, in turn, could lead to suboptimal performance. Consequently, IT managers must determine the "right" level of IT functions based on effective measures of user requirements and satisfaction.

An effective IT management is currently of major concern because recent economic difficulties have forced many corporations to tighten their IT budgets. Nevertheless, firms must find ways to remain competitive with IT. In a broad sense, this study’s findings might aid in this effort. Organizations can maximize their returns from IT investments by capitalizing on the just-in-fit principle, in which neither a shortage nor surplus exists in terms of functional IT supply. Furthermore, since not all TTFs are created equal, and since a high-end fit is superior to a low-end fit, managers should prioritize IT planning and development activities according to the extent to which the IT functions relate to completion of tasks. A priori identification of the optimal balance between IT demand and supply in an organization poses considerable challenges because individual users have diverse requirements. Fit itself is an unstable moving target due to the rapid evolution of technologies. However, companies still can learn from their past experiences in their efforts to find the optimal balance to maximize returns from their investments.

6.3. Limitation and Future Research

This study is not without its limitations. One shortcoming stems from the fact that the results of this study are solely based on the example of groupware systems, which potentially limits their generalizability to other IT systems. For example, a large number of IT functions might be necessary in certain environments (e.g., a research lab) in which users are highly skilled and fully capable of leveraging an abundance of IT functionalities. In such contexts, the fit at equilibrium may not necessarily lead to an optimal performance outcome. Nevertheless, groupware is one of the most widely used applications for group communication and coordination in contemporary organizations. Therefore, our findings may be applicable to many contemporary organizations, especially those that rely heavily on group-based coordination, and provide a new perspective regarding the dynamics between the extent of fit and performance.

We should also point out potential caveats for determining task characteristics. Because this study’s primary focus was the extent of fit, tasks not directly related to IT functions (i.e., creativity) were excluded. Tasks unrelated to IT do not require IT support; thus, only the task value itself (with no reference to IT) represents the extent of fit. This biased fit measure may misinterpret the relationship between fit and performance. Previous fit studies in the IS field, including that of Goodhue and Thompson (1995), also exhibit this limitation.

Another limitation involves the acute parsimony in the model construction, particularly in terms of the variety of independent variables. Although the independent variables explain over 30 percent of the variance of the dependent variables (IS use and task performance), many other factors, either endogenous or exogenous, may also influence the outcome of the explanatory variables. For example, when a decentralized, team-based network environment systematizes information systems, the strength of members’ social relationships may play a role in the adoption of the systems (Huang & Wei, 2000). Moreover, the relationship between IS designers and users could also be critical for IS adoption, use, and task performance in certain contexts. Thus, users' relationships with both the developers and other users may be factored into the performance equation in future studies. Many other variables can be also included as moderators, such as user demographics (e.g., job experience), task characteristics (e.g., structured vs. unstructured), and technology characteristics (e.g., simple vs. complicated systems). These extensions would provide a more holistic view of TTF and its organizational impact.

Finally, since we collected our data from one large financial organization, our results may not be generalizable to other organizations, particularly small companies/institutions in other industries. Future research should validate our findings based on a variety of organizations with a wide range of firm characteristics (e.g., organization size, industry type). Finally, the dependent variables (IS use and task performance) in this study represent users' perceptions, not actual usage or performance. Survey instruments are typically employed in TTF research to gather information about the subjective perceptions, not the actual behaviors, of respondents. Nevertheless, we acknowledge this as one of the limitations of our study. Future studies can replicate the current analysis based on more-objective measures that represent actual usage and performance.

This study also suggests several meaningful directions for future research. Future studies should investigate the validity of the distinction between complementary fit and supplementary fit in the context of TTF, and identify the differential roles and impacts of those two types of fits. The TTF theorizing in this study is grounded primarily in the complementary perspective, which focuses on demand-supply equilibrium. Supplementary fit, on the other hand, relates to value congruence, desirable states or beliefs, the importance of attributes, and the intensity of values (Cable & Edwards, 2004). From this perspective, value congruence between task features and IT functions plays a critical role in determining IT performance. For example, Zigurs and Buckland (1998) used the supplementary fit perspective to examine whether IT support is more effective for simple or complicated task performance. Kristof (1996) explained why it is necessary to consider both types of fit together in order to understand the impacts of fit between the two constructs, particularly when the dependent variable involves attitudinal behaviors. Therefore, future research could compare and contrast these two divergent approaches and investigate their effects on user behaviors and performance.

Furthermore, the moving-target aspect of TTF should be explored in greater depth. To what extent does TTF equilibrium fluctuate between high and low supply and demand? What factors stimulate change in this regard? How should organizations strive to maintain fit when TTF is in a state of fluctuation? These are important research issues requiring further attention in order to advance our knowledge of TTF.

7. Conclusion

Based on a refined conceptualization of TTF and a fresh methodological approach, this study investigated the effects of TTF on perceived IS use and individual task performance. We employed the nonlinear and atomistic fit approaches to conceptualize and evaluate TTF. Further, we identified multiple fit points and their differential effects on performance and assessed the effects of under- versus over-supply of resources on perceived IS use and performance. In addition, the three-dimensional, RSM approach adopted in this study offers an original perspective regarding the effects of TTF on individual performance, which complements the results of studies that utilized traditional two-dimensional linear systems. Our key findings suggest that a good quantitative fit between task and technology leads to increased IS use and improved task performance. Moreover, TTF at the high-end of the equilibrium point contributes positively to perceived IS use and task performance to a greater extent than TTF at the low-end, which indicates that all fits are not created equal. Furthermore, the nonlinear interaction effect of the TTF factors and their locations in the task and technology space were found to be important to better understand the meaning and relative significance of TTF. All these results collectively suggest that managers should wisely allocate their IT resources and effectively prioritize their IT development and planning in such a way that leads to an optimal performance outcome. We hope that this study will expand our understanding of TTF and generate further interest in exploring the complex and dynamic nature of TTF.

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Appendix: Survey Items

Task characteristics: To what extent does each of the following functions is necessary in performing your tasks? (7-point Likert scale: to an extremely large extent, to a very large extent, to a large extent, somewhat, to a small extent, to a very small extent, to an extremely small extent)

1A. Individual communication with each team member (e.g., through email systems).
2A. Communication and discussion with a number of team members at the same time (e.g., through bulletin board).
3A. Attainment, sharing, and assessment of knowledge and information.
4A. Documentation and systematic management and retention of documents.
5A. Workflow management (setting the task procedure by assigning roles and sequences).
6A. Personal Scheduling.

Technology characteristics: To what extent is each of the following functions provided to support your tasks?

1B. Individual communication with each team member (e.g., through email systems).
2B. Communication and discussion with a number of team members at the same time (e.g., through bulletin board).
3B. Attainment, sharing, and assessment of knowledge and information.
4B. Documentation and systematic management and retention of documents.
5B. Workflow management (setting the task procedure by assigning roles and sequences).
6B. Personal Scheduling.

Groupware use

1. Overall dependency on groupware (7-point Likert scale: to an extremely large extent, to a very large extent, to a large extent, somewhat, to a small extent, to a very small extent, to an extremely small extent).

2. Average duration of use per day (7-point Likert scale: rarely - less than 30 minutes - 0.5~1 hour - 1~2 hours - 2~3 hours - 3~4 hour s- more than 4 hours).

3. Average frequency of use per day (7-point Likert scale: rarely – once a day – 2~4 times a day – 4~6 times a day – 6~8 times a day – 8~10 times a day – more than 10 times).

Individual performance improvement after groupware adoption (7-point Likert scale: to an extremely large extent, to a very large extent, to a large extent, somewhat, to a small extent, to a very small extent, to an extremely small extent)

1. Time reduction in task completion.

2. Easier task execution.

3. Capability enhancement in executing tasks.

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