An Empirical Study on the Relationships between the Flexibility, Complexity and Performance of Information Systems Development Projects

Gwanhoo Lee and Weidong Xia
Information and Decision Sciences Department
Carlson School of Management
University of Minnesota
321 19th Avenue South
Minneapolis, MN 55455
Phone: (612) 626-9156, (612) 626-9766
Emails: glee@csom.umn.edu, wxia@umn.edu

January 2003

Acknowledgment: This study was supported by research grants provided by the University of Minnesota and the Juran Center for Leadership in Quality. The Information Systems Specific Interest Group of the Project Management Institute sponsored the collection of the empirical data.
An Empirical Study on the Relationships between the Flexibility, Complexity and Performance of Information Systems Development Projects

Abstract

Information systems development projects (ISDPs) are facing significant challenges due to changes in business and IT environments. To improve IS performance, ISDPs require flexibility to respond to various changes during the project lifecycle.

Drawing upon the flexibility literature and contingency perspectives, this research examines the main effect of ISDP flexibility on IS performance using empirical data collected from 505 ISDP managers. This research also tests the moderating effect of ISDP complexity on the relationship between ISDP flexibility and IS performance.

The results indicate that two types of ISDP flexibility – the extent of response by the project team to various changes and the efficiency of response – have positive main effects on IS performance. Furthermore, the effect of ISDP flexibility on IS performance is stronger when ISDP complexity is higher. This study also found a negative relationship between the two types of ISDP flexibility. We discuss the contributions and limitations of this research. We conclude with directions for future research.
An Empirical Study on the Relationships between the Flexibility, Complexity and Performance of Information Systems Development Projects

Introduction

Today’s business and IT environments are changing at an unprecedented rate. As information systems development projects (ISDPs) involve many complex organizational factors as well as technological elements, the turbulent business and IT environments are becoming significant challenges for ISDP managers. Due to relentless innovation, shorter product life cycles and increasing globalization, business environments are very dynamic and often characterized by such terms as hypercompetition (D'Aveni 1994) and fast-moving high-velocity (Eisenhardt 1989). As a result, information systems under development can be easily outdated and irrelevant. “By the time you design, program, and implement the solution, the world has changed anyway,” says an IS executive in the airlines industry that we interviewed. This statement speaks to the volatility of business requirements that ISDPs must deal with.

IT, at the same time, is changing at an ever-increasing rate (Benamati and Lederer 2001). New technology is invented relentlessly, and current technology becomes easily obsolete. Average product life cycles of IT had declined from 53.6 to 30.8 months between 1988 and 1995 (Hamel and Prahalad 1994). Computing paradigms have shifted from mainframe, to client-server, to web-based computing over the last decade. “You may have a technology that seemed like the right choice at the time, but is obsolete when you put it in,” says an IS manager that we interviewed.

In addition to changes in business and IT environments, complexity of software development work imposes many potential risks on ISDP managers and developers. Indeed, software development is an inherently complex task (Brooks 1995). ISDP managers must
address not only technological but also organizational issues. Typical ISDPs involve various computing platforms, development tools, other systems to be integrated with, users, stakeholders, project sponsors, vendors, and subcontractors. The changes and complexity involved in an ISDP increase the uncertainty that makes it very difficult, if not impossible, for managers to plan and execute their projects.

While business and IT environments become increasingly dynamic and complex, today’s organizations do not appear to be well equipped for handling these challenges effectively. IS organizations have displayed great difficulties in coping with rapid changes and high complexity (Hopper 1996; Murray 2000; Scott 1998). For instance, it has been found that IS organizations do not use effective coping mechanisms to respond to rapidly changing IT environments (Benamati and Lederer 2001). As Senge (1990) argued, conventional forecasting, planning, and analysis methods that most organizations use are not equipped to deal with fast-changing environments. Traditional project management methods become inadequate in highly complex project environments (Williams 1999). A recent Delphi study shows that the rapid changes in business and technological environments are perceived by IS managers as critical risk factors for software development projects (Schmidt et al. 2001).

Both academic and practitioner literatures alike indicate that flexibility is the key in dynamic, complex environments (Alter 2000; Chakravarthy 1997; Evans 1999; Overby 2001). In turbulent environments, flexibility is critical because few commitments succeed exactly as planned. Flexibility is a necessary complement to efficiency and quality for contemporary organizations (Volberda 1998). It facilitates innovation, increases productivity, and helps organizations remain competitive in hypercompetitive environments (Athey and Schmutzler 1995; Brancheau et al. 1996; Volberda 1996). Therefore, it appears critical for IS organizations
to be able to effectively and efficiently respond to environmental changes while implementing ISDPs. Failing to respond to changes during software development may result in irrelevant information systems that users do not accept.

Although both researchers and practitioners came to recognize the importance of flexibility during ISDP implementation, there is a lack of cumulative knowledge and empirical evidence in this research area. Therefore, examining issues and problems surrounding flexibility in the context of ISDPs is timely and much needed. A deeper understanding of ISDP flexibility will provide useful knowledge and insights to improve the historically low IS success rates (Sherer 1992; Standish Group 1994; Standish Group 1998; Standish Group 2001). In this research, we propose that ISDPs require flexibility to deliver information systems that provide high quality functions and meet user needs. Furthermore, using contingency perspectives as a theoretical basis, we propose that the effect of ISDP flexibility on IS performance is stronger when the project context is more complex and uncertain than when it is less complex and certain. Specifically, the primary objectives of this research are to address the following questions:

- Does ISDP flexibility in general improve IS performance?
- Does the positive relationship between ISDP flexibility and IS performance become stronger as the project becomes more complex and uncertain?

This paper is organized as follows. The next section reviews the relevant literatures on flexibility and contingency perspectives. We then define key theoretical constructs for this research. Afterward we develop hypotheses with respect to the effect of ISDP flexibility on IS performance. In the subsequent sections, we discuss the research methods employed in this
study, followed by data analysis results. After discussing the key findings and contributions of this research, we conclude with the limitations of this research and directions for future research.

**Literature Background**

**Flexibility**

Prior IS literature has recognized the importance of ISDP flexibility for coping with the changes and complexity involved in software development. For instance, the effects of the ISDP team’s responsiveness and flexibility on systems functionality, user perceptions, and system usage have been examined (Gefen 2000; Gefen and Ridings 2002). In addition, IS researchers have examined project coordination mechanisms (Andres and Zmud 2002; Nidumolu 1995; Nidumolu 1996) and prototyping strategies (Hardgrave et al. 1999; Naumann and Jenkins 1982) that would increase flexibility to cope with user requirement changes and project complexity. However, little past research has directly examined the flexibility construct in the context of ISDPs. Given the lack of the literature on ISDP flexibility, reviewing a broader range of literature from various reference disciplines may aid in conceptualizing and theorizing ISDP flexibility.

Flexibility has been defined by most of the literatures, including information systems, organization theory, strategic management, and operations management, as the *capability* to respond to environmental changes. This capability-based perspective has conceptualized flexibility in various contexts and levels of analysis. In the strategic management literature, for instance, strategic flexibility is viewed as the capability to develop a firm's strategy to respond to environmental changes in a timely and appropriate manner (Das and Elango 1995). Manufacturing flexibility is defined as a production system's capability of exhibiting a wide range of states or behaviors to meet changing customer demands (Slack 1983). IS researchers
have defined IT infrastructure flexibility as the organizational capability to support a variety of information technologies and information services (Byrd and Turner 2000; Duncan 1995).

Researchers have consistently agreed that flexibility is a complex, multidimensional and hard-to-capture construct (Sethi and Sethi 1990). As a result, many different dimensions and types of flexibilities have been proposed. For example, researchers have distinguished product and process flexibilities (Athey and Schmutzler 1995), resource and coordination flexibilities (Sanchez 1995), operational, structural and strategic flexibilities (Volberda 1996), internal and external flexibilities (Upton 1994), realized and potential flexibilities (Dixon 1992), and speed and variety flexibilities (Volberda 1996). Duncan (1995) measured the flexibility of platform, network/telecommunication, data, and applications along dimensions including compatibility, connectivity, and modularity. Byrd and Turner (2000) measured IT infrastructure flexibility with such dimensions as IT connectivity, application functionality, IT compatibility, data transparency, technology management, business knowledge, management knowledge, and technical skills.

Recently, the notion of dynamic capability has gained attention from management researchers. Dynamic capabilities are defined as the firm’s abilities to integrate, build, and reconfigure internal and external resources, competences and capabilities to address rapidly changing environments (Eisenhardt and Martin 2000; Teece et al. 1997). Flexibility is enhanced by developing various dynamic capabilities (Volberda 1998).

Another line of research views flexibility as options available to the organization. According to Mason and Merton (1985), flexibility is nothing but a description of the options made available to management as part of the project. From the option theoretical perspective, firms should delay commitment (thus have more flexibility) until key uncertainties have been resolved and the scenario that will prevail in the future is more certain (Ghemawat and del Sol
1998). IS researchers also have used this perspective of flexibility to assess IT investment decision making (Benaroch 2002; Benaroch and Kauffman 2000).

Flexibility has been found to improve organizational performance (Narasimhan and Das 1999b; Paik 1991; Tatikonda and Rosenthal 2000). Although flexibility has been found to be beneficial in general, the effect of flexibility may vary depending on the organizational environment and context (Volberda 1998). Contingency perspectives provide a useful theoretical framework for theorizing the differential effects of ISDP flexibility on IS performance under different contexts. Since the primary contention of this research is based on contingency perspectives, we briefly review them in the following section.

**Contingency Perspectives**

The classical contingency theory asserts that different external conditions might require different organizational characteristics, and that the effectiveness of the organization is contingent upon the amount of congruence or goodness of fit between environmental and structural variables (Burns and Stalker 1961; Lawrence and Lorsch 1967; Pennings 1992; Van de Ven and Drazin 1985). Conversely, misfits or mismatches between such dimensions are held to reduce organizational performance (Huizing, Koster, and Bouman 1997). The classical contingency theory has primarily examined the fit between organizational context and organizational structure. Structural variables that have been studied include differentiation, integration, centralization, and formalization (Lawrence and Lorsch 1967). Furthermore, other organizational factors like process, culture, and strategy have been examined.

IS research has extensively used contingency perspectives (Weill and Olson 1989). In particular, contingency perspectives have been adopted by IS researchers to examine IS development strategies and processes (Franz 1985; Nidumolu 1996). Andres and Zmud (2002)
examined the moderating effect of task interdependence on the relationship between software project coordination strategy and development productivity. Hardgrave et al. (1999) developed a contingency model for prototyping strategies under various project environments.

While correlations between structural and environmental attributes have been well studied when the organization is the level of analysis, they have been much less investigated in the project context (Shenhar 2001). Projects can be seen as “temporary organizations within organizations” (Shenhar 2001). Therefore, the logic of contingency theory can be applied for the level of projects as well as that of organizations. Recently, the need for using contingency perspectives for the study of projects has been widely recognized (Yap and Souder 1994, Eisenhardt and Tabrizi 1995, Balachandra and Friar 1997, Brown and Eisenhardt 1997, Sounder and Song 1997, Song et al. 1997).

Classical contingency theory suggests that the complexity and dynamism of organizational environments are strong moderators for the relationship between flexibility and performance (Judge and Miller 1991; Nayyar and Bantel 1994). Consistently, prior literature suggests complexity and dynamism as two major dimensions of project context (Shenhar 2001).

The environmental complexity includes not only the number of factors but also the interdependencies of these factors (Duncan 1972; Lawrence 1981). On the other hand, environmental dynamism refers to the rate of change in the environment and the unpredictability of environmental changes (Duncan 1972; Miller and Friesen 1982). Researchers have often used the term, complexity, to include both structural complexity (i.e., number of components and relationships) and dynamic complexity (i.e., rate of change) because these two constructs closely relate to each other and collectively increase uncertainty (Duncan 1972; Williams 1999; Wood 1986).
Definitions and Dimensions of Constructs

Before we develop our hypotheses on the effects of ISDP flexibility on IS performance, we define key theoretical constructs. Since ISDP flexibility, ISDP complexity, and IS performance are ambiguous, multidimensional constructs (DeLone and McLean 1992; Nidumolu 1995; Sethi and Sethi 1990; Wood 1986), it is important to clearly state how we define those constructs. By so doing, we may avoid unnecessary confusion when we discuss the relationships among the constructs.

ISDP Flexibility

The Merriam-Webster’s Dictionary defines ‘flexible’ as ‘characterized by a ready capability to adapt to new, different, or changing requirements.’ The ISDP managers we interviewed typically defined “flexibility” as “the ability of an ISDP team to deal with new things coming up without incurring much costs,” “being able to continually evaluate what is going on and take reactions to changes,” and “being able to effectively respond to any changes.” Following the capability-based perspectives, in this research, we define ISDP flexibility as the ISDP team’s capability to effectively and efficiently respond to project environmental changes (Lee and Xia 2002). Project environmental changes include changes in both business requirements and IT during the project’s implementation. Business requirement changes include changes in system scope, business processes, and input and output requirements. IT changes include changes in software development tools, network environment, IT architecture, and other related systems that will be integrated with the system being developed.

Although ISDP flexibility may have many different dimensions (Athey and Schmutzler 1995; Lee and Xia 2002; Sethi and Sethi 1990), we particularly focus on the following two types that represent different facets of ISDP flexibility. The first type of ISDP flexibility is the extent
of the project team’s response to business and IT changes. The extent of response indicates the proportion of changes that the project team actually incorporates into their software development work. The larger the extent of response by the project team, the more flexible the project. This dimension of flexibility has been considered one of the major facets of flexibility (Bahrami 1992; Das and Elango 1995; Sanchez 1993; Slack 1983).

The second type of ISDP flexibility that we examine is the efficiency of the project team’s response to business and IT changes. The efficiency of response refers to how much additional effort is required to handle the changes. A high degree of additional effort indicates a low degree of flexibility. This dimension of ISDP flexibility taps into the level of penalty associated with flexibility (Athey and Schmutzler 1995; Nelson and Ghods 1998; Young-Ybarra and Wiersema 1999).

When assessing ISDP flexibility, we may measure either potential flexibility, realized (actualized) flexibility, or both (Gerwin 1993). Potential flexibility is inherent to an existing organization, and it should be distinguished from realized flexibility allocated by management to a real flexibility needs (Volberda 1998). Measuring potential flexibility is very difficult and problematic, if not impossible (Slack 1983). This research focuses on realized ISDP flexibility rather than potential ISDP flexibility. That is, this research is primarily interested in how much and how well the project team activates potential flexibility to cope with changing environments.

**ISDP Complexity**

Following prior literature in task complexity and project complexity (Williams 1999; Wood 1986), we define ISDP complexity as a construct that includes both structural complexity and dynamic complexity. Structural complexity is a function of the number of project components and the form and strength of the relationships between the components. Dynamic
complexity indicates the complexity caused by changes in project components and their relationships. Both structural and dynamic complexities can be further classified into organizational and technological dimensions (Baccarini 1996). Taken together, we define ISDP complexity as a multidimensional construct consisting of four components: structural organizational complexity, structural IT complexity, dynamic organizational complexity, and dynamic IT complexity (Xia and Lee forthcoming).

The structural organizational complexity reflects the nature and strength of the relationships between the project elements and the organizational supporting environment, such as project resources, top management and user support, project staffing, and the skill proficiency levels of the project personnel. The structural IT complexity captures the coordinative complexity among the IT elements, reflecting the diversity of user units, software environments, nature of data processing, variety of technology platform, need for integration, and the diversity of external vendors and contractors. The dynamic organizational complexity captures the rate of changes in organizational environments, including changes in user information needs, business processes, and organizational structures. It also reflects the dynamic nature of the project’s impact on the organizational environment. The dynamic IT complexity measures the rate of changes in the IT environment of the ISDP, including changes in IT infrastructure, architecture and software development tools.

**IS Performance**

Past research proposed a number of measures to assess IS performance (DeLone and McLean 1992). We use *systems functionality* and *user satisfaction* to measure the performance of the information system delivered by the project. These measures have been well accepted and widely used in prior research (Cooprider and Henderson 1991; Deephouse et al. 1996; Nidumolu
System functionality concerns how well the system meets the functional goals and the actual needs of the intended users. User satisfaction refers to the extent to which users are satisfied with the information system delivered by the project, in terms of sufficiency and usefulness of information provided, output format, ease of use, etc (Doll and Torkzadeh 1988).

Hypotheses Development

Before we develop the hypotheses for the effects of ISDP flexibility on IS performance, we first propose a relationship between the two types of ISDP flexibility. Specifically, the extent of response by the ISDP is hypothesized to negatively affect the efficiency of response. Suppose an ISPD team is committed to respond to changes to a large extent. To respond to many changes, the ISDP team needs to handle not only familiar/predictable changes but also unfamiliar/unpredictable changes. In this case, it is likely that the project team needs to acquire new knowledge, skills, expertise, and new capabilities in order to address unfamiliar changes that their current capabilities cannot cope with. More experimentation, exploration, and learning are likely to be involved (March 1991). As a result, it takes significant additional efforts to create and activate new capabilities (Teece et al. 1997), thus decreasing the efficiency of response.

In contrast, suppose the project team chooses to selectively respond to a few changes. Then, the project team can focus on changes that are familiar and predictable, and may not need to acquire new skills, expertise, and capabilities to handle unfamiliar changes. As a result, specialized routines that handle familiar changes can be developed, and it would take less time and effort to activate project capabilities and routines to respond to changes (Volberda 1998). Specialized routines provide an organizational memory for handling changes and eliminate the need for extensive communication and coordination among project team members, thus increasing the efficiency of response. Taken together, we propose:
Hypothesis 1. The extent to which an ISDP team responds to business and IT changes negatively affects the efficiency of response by the ISDP team.

Main Effects of ISDP Flexibility on IS Performance

Developing and maintaining flexibility may incur additional costs because, in many cases, flexibility is not free (Ghemawat and del Sol 1998). Nevertheless, flexibility appears to be valuable, in general, because it allows organizations to achieve dynamic efficiency (Ghemawat and Costa 1993). Prior IS research suggests that increased flexibility in software development projects have positive main effects on IS performance. Gefen and Ridings (2002) found in their quasi-experimental study that the ISDP team’s responsiveness and flexibility to user needs and requests for enhancements improved the correctness of the CRM (Customer Relationship Management) system configuration. The increased correctness of the system configuration, in turn, positively affected user approval and acceptance of the system. An ISDP team’s flexibility in response to user needs has also been found to increase system usage through increased perceived usefulness and ease of use of the system (Gefen and Keil 1998).

In addition, it has been found that an organic coordination strategy in ISDPs, which increases flexibility to external changes, had positive main effects on software development productivity and user satisfaction (Andres and Zmud 2002). Increased information exchange due to an organic coordination strategy makes the project team more sensitive and responsive to problems and changes during the project’s implementation. As a result, the project team executes tasks more effectively and efficiently.

The positive main effect of flexibility on performance has also been supported by other reference disciplines including organization theory, strategic management, and operation
management. Tatikonda and Rosenthal’s (2000) study supports that a greater degree of resource flexibility leads to higher performance in product development projects. Strategic flexibility (e.g., Paik and Jacobson 1993; Stopford and Baden-Fuller 1990; Worren et al. 2002) and manufacturing flexibility (e.g., Narasimhan and Das 1999a) demonstrated positive impacts on organizational performance.

Consistent with prior literature, we propose that the two types of ISDP flexibility have positive main effects on IS performance. ISDP flexibility enables the project team to be able to build the information system that incorporates business and IT changes occurred during project implementation. It may even enable the team to capitalize on the opportunities presented by changing environments to deliver high quality systems that satisfy users. If the ISDP team responds to changes to a larger extent, the system delivered is more likely to meet users’ current needs and requirements. In contrast, failing to respond to important requirement changes may result in a system that users would not accept.

When the ISDP team is not efficient in handling changes, substantial additional resources are required. As a result, much additional coordination work is also required. A high degree of coordination work increases not only project time/cost but also system defects, thus decreasing user satisfaction. Taken together, we propose:

_Hypothesis 2. As an ISDP team responds to business and IT changes to a larger (lesser) extent, IS performance increases (decreases)._  

_Hypothesis 3. As an ISDP team responds to business and IT changes more (lesser) efficiently, IS performance increases (decreases)._
Moderating Effects of ISDP Complexity on the Flexibility-Performance Relationship

While the positive main effect of ISDP flexibility on IS performance exists, the strength of the effect may vary depending on the degree of ISDP complexity. Andres and Zmud (2002) found a significant interaction effect between task interdependence and software project coordination strategy for development productivity. As software design and coding tasks become more task interdependent (i.e., task complexity), the greater the effect of an organic (i.e., flexible) coordination strategy on project team productivity. Hardgrave et al. (1999) developed a contingency model that proposed appropriate prototyping strategies contingent upon five project characteristics including project innovativeness (i.e., project uncertainty). The study found that evolutionary prototyping, which increases flexibility and adaptability of software development, had stronger impacts on IS performance when the project is more innovative.

In addition to IS research, the strategic management literature indicates that the impact of flexibility on organizational performance depends on the complexity and uncertainty of external environments (Nayyar and Bantel 1994). Eisenhardt (1989) and Judge and Miller (1991) found that flexibility in decision-making process was associated with higher organizational performance in highly complex and uncertain environments such as high-tech industries.

Following past research, we propose that ISDP complexity moderates the strength of the effect of ISDP flexibility on IS performance. The higher ISDP complexity is, the higher the degree of uncertainty involved in the project. In low ISDP complexity, the need for flexibility will be less evident. In such environments, the effect of flexibility on performance is marginal, so managers are more likely to achieve higher performance by fine-tuning and focusing on existing operations and routines rather than expending resources on building flexibility. Flexibility entails certain disadvantages including high cost, increased stress, and a potential lack
of focus (Das and Elango 1995). Therefore, when an ISDP has low complexity, ISDP flexibility may result in marginal benefits.

In contrast, when an ISDP exhibits high complexity, flexibility may be a significant way to improve organizational performance (Das and Elango 1995). In environments characterized by continuous changes and high complexity, the implementation of flexibility is a very important element for superior performance. Highly complex ISDP contexts will allow the project to gain the full benefits of its flexibility. Taken together, we propose:

**Hypothesis 4.** As ISDP complexity becomes higher (lower), the extent of response by an ISDP team to business and IT changes has a greater (lesser) positive effect on IS performance.

**Hypothesis 5.** As ISDP complexity becomes higher (lower), the efficiency of response by an ISDP team to business and IT changes has a greater (lesser) positive effect on IS performance.

**Research Methods**

**Sample and Data Collection**

Our primary research method involved a large-scale, project-level, cross-sectional survey. A web-based survey was administered to IS project managers. The source for the sample was the Information Systems Specific Interest Group of the Project Management Institute (PMI-ISSIG). The PMI-ISSIG is an international organization for current or prospective project managers in the information systems field. Given that a large portion of the PMI-ISSIG members were not current IS project managers, we used three criteria to select our target respondents. The criteria were (1) North American PMI-ISSIG members who (2) were project
managers excluding specialists such as programmer or systems analysts, and (3) had managed a recently completed ISDP. The reason for choosing North American members was to minimize bias and noise caused by language problems that the non-English speaking members in the other regions might have. As a result, we identified a target group of 1,740 IS project managers who met all of the three criteria and had a valid email address in the membership database.

The PMI-ISSIG sponsored this research by providing membership information and promoting the survey to their members. A PMI-ISSIG-sponsored email letter with a hyperlink to the web-based survey was sent to the target group. Likert-type scales were used. The items were randomized to minimize any bias from the survey method. To encourage participation, survey participants were entered into a drawing to receive one of ten golf shirts with a PMI-ISSIG imprint or one of forty $25.00 gift certificates from a well-known online store. A follow-up reminder was sent two weeks after the first notice email. A second reminder email was sent four weeks after the first notice.

In total, 565 responses were received, representing a response rate of 32.5%. After incomplete or invalid data cases were dropped, 505 usable responses were retained for the data analysis for this research. Thus a final effective response rate was 29.0%. Given that the survey was administered to a large number of (busy!) managers, this response rate can be considered relatively high. Table 1 shows the sample characteristics. The sample includes various industry sectors, including manufacturing, financial services, software, consulting, retailing, transportation, healthcare, and utility. The sample well represents all of small, medium, and large companies in terms of annual sales and the number of employees. On average, companies in the sample had annual sales of $2.5 billion and 14,786 employees. Projects in the sample almost evenly represented three types of ISDPs: new in-house development (37.3%), packaged
software implementation (34.8%), and enhancement of existing software (27.9%). Projects had an average budget of $2 million, 34 team members, and duration of 12 months.

Table 1. Characteristics of the sample (n = 505)

<table>
<thead>
<tr>
<th>Characteristics of organizations</th>
<th>Characteristics of projects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry category</strong></td>
<td><strong>Type of project</strong></td>
</tr>
<tr>
<td>Consulting</td>
<td>In-house new development</td>
</tr>
<tr>
<td>Finance/Insurance</td>
<td>Packaged software implementation</td>
</tr>
<tr>
<td>Government</td>
<td>Enhancement of existing software</td>
</tr>
<tr>
<td>Healthcare</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td></td>
</tr>
<tr>
<td>Software</td>
<td></td>
</tr>
<tr>
<td>Telecom/network</td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
</tr>
<tr>
<td>Utility</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td><strong>Sales</strong></td>
<td><strong>Number of project members</strong></td>
</tr>
<tr>
<td>Less than $100 million</td>
<td>Less than 10</td>
</tr>
<tr>
<td>$100 million - $1 billion</td>
<td>10 – 50</td>
</tr>
<tr>
<td>Over $1 billion</td>
<td>Over 50</td>
</tr>
<tr>
<td><strong>Project budget</strong></td>
<td></td>
</tr>
<tr>
<td>Less than $100,000</td>
<td></td>
</tr>
<tr>
<td>$100,000 – 1 million</td>
<td></td>
</tr>
<tr>
<td>Over $1 million</td>
<td></td>
</tr>
<tr>
<td><strong>Project duration</strong></td>
<td></td>
</tr>
<tr>
<td>Less than 6 months</td>
<td></td>
</tr>
<tr>
<td>6 – 12 months</td>
<td></td>
</tr>
<tr>
<td>Over 12 months</td>
<td></td>
</tr>
<tr>
<td><strong>Number of employees</strong></td>
<td></td>
</tr>
<tr>
<td>Less than 1,000</td>
<td></td>
</tr>
<tr>
<td>1,000 – 10,000</td>
<td></td>
</tr>
<tr>
<td>Over 10,000</td>
<td></td>
</tr>
</tbody>
</table>

**Measures**

**Measurement development and validation process**

We developed new measures for ISDP flexibility and ISDP complexity because prior literature did not provide appropriate measures for these constructs. We aimed to develop measures that tap into the context of IS development. However, we used existing measures for IS performance because valid, reliable measures were available from past research (Deephouse et al. 1996; Doll and Torkzadeh 1988; Jiang and Klein 2001; Nidumolu 1995; Weitzel and Graen 1989). We used a systematic four-phase process involving a variety of methods to develop and validate the measurement of ISDP flexibility and ISDP complexity. This measurement
development process involved groundwork including field interviews and focus group
discussions with a number of IS executives and managers. The four phases are (1) conceptual
development and initial item generation, (2) conceptual refinement and item modification, (3)
data collection, and (4) measurement validation (See Xia and Lee(2002) for the detailed
description of the measurement development process).

Following the two-step approach to structural equation modeling (Anderson and Gerbing
1988), we first developed measurement models for the constructs before examining the structural
model to test the hypothesized relationships between constructs. We assessed, validated, and
refined the psychometric properties of the measurement models. What follows is the
measurement model for each construct and discussion on its measurement properties.

**ISDP flexibility**

As we discussed earlier, we distinguish two types of ISDP flexibility: *the extent of
response* and *the efficiency of response*. After refining items through pretests and pilot tests,
twenty items were retained for each type of ISDP flexibility in the final survey instrument.
Using a confirmatory factor analysis (CFA), we further refined the measurement. Figure 1
shows the final measurement model of the first type of ISDP flexibility, the extent of response.
The construct *FEXT* is a second-order latent variable consisting of two first-order latent variables.
*FEXTB* includes 8 items that measure the extent of response by the ISDP team to various
business requirement changes. *FEXTT* includes 5 items measuring the extent of response by the
project team to various IT changes. All estimated parameters were significant at the 99 percent
confidence level. The descriptions of the items along item codes are shown in Appendix A.
This measurement model demonstrates satisfactory levels of fit as indicated by multiple fit
indices (Figure 1). The two first-order constructs exhibited high degrees of reliability measured
by composite reliability $\rho_c$ (Werts et al. 1974): 0.92 for FEXTB and 0.91 for FEXTT.

Furthermore, each factor demonstrates satisfactory levels of unidimensionality and discriminant validity (Appendix A).

![Diagram of measurement model](image_url)

**Fit indices:** $\chi^2$/d.f.=217.17/64=3.39 GFI=.94 AGFI=.91 RMSEA=.069 RMR=.041 CFI=.97

Note: All estimated parameters are significant at the 99 percent confidence level.

Figure 1. A measurement model of ISDP flexibility (extent of response) (n = 505)

Figure 2 shows the measurement model of the second type of ISDP flexibility, the efficiency of response. The second-order construct FEFF consists of two first-order latent variables. FEFFB has 7 items for measuring the efficiency of response by the ISDP team to various business requirement changes. FEFFT includes 5 items measuring the extent of response to various IT changes. All estimated parameters were significant at the 99 percent confidence level. The descriptions of the items along item codes are shown in Appendix A. This measurement model demonstrates satisfactory levels of fit, as indicated in Figure 2. The first-order constructs exhibited satisfactory levels of reliability ($\rho_c$): 0.88 for FEFFB and 0.86 for
FEFFT. Finally, this measurement model demonstrates satisfactory levels of unidimensionality and discriminant validity, as shown in Appendix A.

![Diagram of ISDP flexibility measurement model](image)

Fit indices: $\chi^2/d.f.=187.58/53=3.54$ GFI=.94 AGFI=.91 RMSEA=.071 RMR=.053 CFI=.96

Note: All estimated parameters are significant at the 99 percent confidence level.

Figure 2. A measurement model of ISDP flexibility (efficiency of response) (n = 505)

**ISDP complexity**

ISDP complexity is conceptualized as a multidimensional construct consisting of four distinct components of complexity. Figure 3 illustrates a second-order measurement model of ISDP complexity. The descriptions of the items along item codes are provided in Appendix B. *SORG* (structural organizational complexity) includes five items. *SIT* (structural IT complexity) includes seven items. *DORG* (dynamic organizational complexity) and *DIT* (dynamic IT complexity) include five and three items, respectively. The measurement model exhibits satisfactory levels of goodness of fit (Figure 3). The existence of the second-order factor, ISDP complexity, is supported by a very high target coefficient ($T = .98$) (Marsh and Hocevar 1985). Four first-order constructs exhibited satisfactory levels of reliability ($\rho_c$): 0.73 for SORG, 0.77
for SIT, 0.81 for DORG, and 0.88 for DIT. Each of the four first-order constructs demonstrates satisfactory levels of unidimensionality and discriminant validity (Appendix B).

Fit indices: \( \chi^2/d.f.=512.39/166=3.09 \) GFI=.91 AGFI=.88 RMSEA=.064 RMR=.064 CFI=.89

Note: All estimated parameters are significant at the 99 percent confidence level.

Figure 3. A measurement model of ISDP complexity (n=505)

**IS performance**

IS performance measures were adapted from prior literature; the measures from Nidumolu (1995) and Weitzel and Graen (1989) were used for system functionality, and the measures from Doll and Torkzadeh (1988) and Jiang and Klein (2001) were used for user
satisfaction measures. As shown in Figure 4, user satisfaction and systems functionality included three items and four items, respectively. The descriptions of the items along item codes are shown in Appendix C.

![Measurement Model Diagram](image)

Fit indices: $\chi^2$/d.f.=73.16/13=5.63 GFI=.96 AGFI=.91 RMSEA=.097 RMR=.030 CFI=.98
Note: All estimated parameters are significant at the 99 percent confidence level.

Figure 4. A measurement model of IS performance (n=505)

IS performance is viewed as a second-order latent variable (PERF) underlying the two first-order latent variables: systems functionality (FUNC) and user satisfaction about the system (USAT). This measurement model demonstrates sufficient levels of goodness of fit as indicated by Figure 4. Two first-order constructs exhibited satisfactory levels of reliability ($\rho_c$): 0.88 for FUNC and 0.90 for USAT. Finally, unidimensionality and discriminant validity were satisfactory (shown in Appendix C).

**Hypothesis Testing Procedure**

Our analytical purpose was to examine (1) the main effects of ISDP flexibility on IS performance and (2) the moderating effects of ISDP complexity on the relationships between ISDP flexibility and IS performance. To achieve this purpose, we first examine the hypothesized structural equation model (Figure 5) with the whole sample (n = 505). Using the measurement
models illustrated in Figures 1, 2, and 4, this structural equation model specifies the relationships between two types of ISDP flexibility and IS performance. Hypotheses 1 to 3 are tested by examining the statistical significance of the estimates of structural paths between ISDP flexibility and IS performance.

To test the contingency hypotheses (Hypotheses 4 and 5), we split the sample into two groups based on the composite score of ISDP complexity scale. We used $\lambda$ weights obtained from Figure 3 to calculate the composite score. Using the composite score, we split the sample into two groups: projects with a composite score higher than 4 out of 7 into the high ISDP complexity group and projects with a composite score lower than 4 into the low ISDP complexity group. This classification scheme resulted in 202 projects for the high ISDP complexity group and 303 projects for the low ISDP complexity group. We then used a two-group LISREL model to estimate the parameters and to test for significant differences of the parameters between the two groups (Bollen 1989).

The two-group analysis was conducted through the following steps. First, we performed a two-group analysis to derive parameter estimates for each group separately and to assess the model fit for both groups considered simultaneously. This two-group structural equation model serves as a baseline model to test moderating effects. We then compare the baseline model with a constrained model in which the pair of path coefficients from the two groups are forced to be equal. A moderating effect is supported if the $\chi^2$ difference between the two models is significant.
Note: FEXT = extent of response; FEXTB = extent of response to business changes; FEXTT = extent of response to IT changes; FEFF = efficiency of response; FEFFB = efficiency of response to business changes; FEFFT = efficiency of response to IT changes; PERF = IS performance; FUNC = systems functionality; USAT = user satisfaction; $\gamma_i$ = structural model coefficients (from exogenous to endogenous latent variables); $\beta_i$ = structural model coefficients (between endogenous latent variables); $\zeta_i$ = structural model error terms; $\lambda_i$ = measurement model coefficients; $\epsilon_i$ = measurement model error terms.

Figure 5. The hypothesized structural equation model

Choice of Fit Indices

A number of fit indices have been developed and proposed over the last two decades (Byrne 1998). When it comes to the analysis of a large model with many indicators, the widely-used Goodness-of-Fit Index (GFI) is not an appropriate criterion (Gerbing et al. 1994). A severe downward bias of GFI for large models has been found (Gerbing and Anderson 1992). Our hypothesized structural equation model is quite large, including 32 indicators. Following Gerbing, Hamilton, and Freeman (1994), therefore, we use the Comparative Fit Index (CFI), instead of GFI, as the primary fit index. In addition, we use the Root Mean Square Error of Approximation (RMSEA), the Standardized Root Mean Square Residual (RMR), and the Chi-
square/Degrees of Freedom Ratio ($\chi^2$/d.f.) as complementary fit indices. Prior literature suggests that a good fit is indicated by CFI above .90, RMSEA less than .08, Standardized RMR less than .10, and $\chi^2$/d.f. smaller than 5 (Byrne 1998; Chin and Todd 1995; Hu and Bentler 1995; Jöreskog and Sörbom 1989; Wheaton et al. 1977).

**Results**

Figure 6 reports the fit indices and the parameter estimates for the hypothesized structural equation model based on the whole sample (n = 505). The results suggest that the hypothesized model fits the data well; the fit indices demonstrate satisfactory levels (CFI = .92, RMSEA = .064, RMR = .053, $\chi^2$/d.f. = 1400.66/455 = 3.08). All estimated coefficients are significant at the 99 percent confidence levels. All first-order latent variables are highly associated with their corresponding second-order latent variables, indicating that the measurement models are valid in the hypothesized structural equation model. The extent of response by an ISDP team to changes is found to be negatively associated with the efficiency of response, supporting Hypothesis 1. In addition, the extent of response positively affects IS performance, supporting Hypothesis 2. The efficiency of response by the ISDP team to change also positively affects IS performance, supporting Hypothesis 3.

The extent of response has both direct and indirect effects on IS performance. The indirect effect is mediated by the efficiency of response. Taking direct and indirect effects together, we found that the total effect of the extent of response on IS performance was significant and positive ($t = 2.89, p < .01$).
Figure 6. Estimated structural equation model of the impacts of ISDP flexibility (n=505)

The results of the two-group structural equation model are shown in Figure 7 (See Appendix D for the covariance matrix). The fit indices of the two-group model indicate a satisfactory model fit with the data (CFI = .91, RMSEA = .065, RMR = .058, $\chi^2$/d.f. = $1922.39/910 = 2.11$). In this model, all parameters in two groups were estimated simultaneously. All coefficients in two groups are significant at the 99 percent confidence levels. The results indicate that the positive effect of ISDP flexibility on IS performance exists not only for the high ISDP complexity group but also for the low ISDP complexity group.
(a) High ISDP complexity group (n₁=202)

(b) Low ISDP complexity group (n₂=303)

Fit indices: CFI = .91, RMSEA = .067, RMR = .059, $\chi^2$/d.f. = 2.11
Note: All estimated coefficients are significant at the 99 percent confidence levels.

Figure 7. Estimated structural equation models based on a two-group analysis

To test the contingency hypotheses, we compared this baseline two-group model with a constrained two-group model in which a pair of path coefficients are assumed to be equal. Table 2 reports the path coefficients for two groups from the baseline two-group model and $\chi^2$ differences between the baseline model and the constrained models. The positive effect of the
extent of response on IS performance was significantly stronger in the high ISDP complexity group than in the low ISDP complexity group ($\Delta \chi^2 = 7.70, p < .01$). The positive effect of the efficiency of response on IS performance was significantly stronger in the high ISDP complexity group than in the low group ($\Delta \chi^2 = 5.66, p < .05$). The results, therefore, supported Hypotheses 4 and 5. The total effect of the extent of response on IS performance was significant for the high ISDP complexity group (t = 2.87, p < .01) but was not significant for the low ISDP complexity group (t = 1.13, p > .05). However, the relationship between the two types of ISDP flexibility was not significantly different across two groups (t = 0.12).

Table 2. Moderating effects of ISDP complexity

<table>
<thead>
<tr>
<th>Path</th>
<th>Parameter</th>
<th>Standardized coefficients (t statistic)</th>
<th>$\Delta \chi^2$ (d.f.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEXT TO PERF</td>
<td>$\gamma_{71}$</td>
<td>.87 (5.04)</td>
<td>.53 (4.09)</td>
</tr>
<tr>
<td>FEFF TO PERF</td>
<td>$\beta_{78}$</td>
<td>.94 (4.55)</td>
<td>.60 (3.84)</td>
</tr>
<tr>
<td>FEXT TO FEFF</td>
<td>$\gamma_{81}$</td>
<td>-.66 (-6.07)</td>
<td>-.62 (-6.92)</td>
</tr>
</tbody>
</table>

Note: Chi-square values greater than 3.84 are significant at the 95 percent confidence level; values greater than 6.63 are significant at the 99 percent confidence level.

* p < .05   ** p < .01

Discussion

Main effects of ISDP flexibility

The results indicate that the hypothesized structural equation model is well supported by the entire sample of our empirical data. In addition, the main effects of ISDP flexibility on IS performance were supported. The standardized coefficient for the main effect of the efficiency of response ($\beta_{78}$) is larger than that for the main effect of the extent of response ($\gamma_{71}$). However, a chi-square test shows that the difference is only marginally significant ($\chi^2(1) = 3.71, p < .1$).
This result indicates that both types of ISDP flexibility have about the same level of direct effect on IS performance.

The negative effect of the extent of response on the efficiency of response suggests a trade-off relationship between the two types of ISDP flexibility. That is, an ISDP team may not be able to increase both types of ISDP flexibility simultaneously. Therefore, there should exist an optimal extent of response by the ISDP team to environmental changes for maximizing IS performance.

The extent of response exhibited a negative indirect effect (t = -5.70, p < .01) as well as a positive direct effect (t = 6.70, p < .01) on IS performance. The total effect was significantly positive, indicating that the net value of the extent of response is positive.

**Moderating Effects of ISDP Complexity**

The two types of ISDP flexibility demonstrated significant direct effects on IS performance not only for the high ISDP complexity group but also for the low ISDP complexity group. These results suggest that ISDP flexibility matters even when ISDP complexity is low. However, as we hypothesized, the strengths of the effects were significantly different across two groups, indicating that the benefit of ISDP flexibility is larger when ISDP complexity is higher. Thus, the moderating effect of ISDP complexity on the relationship between ISDP flexibility and IS performance was supported. Neither the high ISDP complexity group ($\chi^2 (1) = 1.11, p > .1$) nor the low group ($\chi^2 (1) = 1.14, p > .1$) exhibited any significant differences in the strengths of the direct effects of the two types of flexibility on IS performance.

The negative effect of the extent of response on the efficiency of response was supported in both high and low ISDP complexity groups. There was no significant difference in the strength of the effect across the two groups ($\chi^2 (1) = 0.12, p > .1$). This result indicates that the
negative relationship between the two types of ISDP flexibility may be inherent to ISDPs and not affected by the degree of project complexity.

In the high ISDP complexity group, the extent of response exhibited a positive direct effect \( t = 5.04, p < .01 \), a negative indirect effect \( t = -3.83, p < .01 \), and a positive total effect \( t = 2.87, p < .01 \) on IS performance. In the low complexity group, the extent of response exhibited a positive direct effect \( t = 4.09, p < .01 \), a marginally significant negative indirect effect \( t = -1.79, p < .1 \), and a non-significant total effect \( t = 1.13, p > .01 \) on IS performance. These results indicate that ISDP complexity moderates not only direct effects but also total effects of ISDP flexibility on IS performance.

**Implications for Theory and Practice**

This research significantly contributes to theory. To the best of our knowledge, the current study is a first attempt to directly apply the flexibility construct for ISDP contexts and to empirically test its effect on IS performance. Drawing upon contingency perspectives, this research makes a strong case that flexibility is a critical project capability, particularly in complex project environments.

This research extends the contingency perspectives along two directions. First, while a majority of studies from contingency perspectives have examined the organizational level variables, this research examined the project level variables, which is a relatively new level of analysis for contingency theory literature. Recently, researchers recognized the need for using contingency perspective in the study of software project management (Shenhar 2001).

Second, the current study extends the domain of ‘fit’ into capability variables. Most prior contingency theory literature examined the fit between environmental contexts and structural variables such as centralization/decentralization, organic/mechanistic structure, differentiation,
and integration. Consistent with dynamic capability perspectives (Teece et al. 1997), this research maintains that project capabilities need to be built contingent upon project contexts. Therefore, this research makes a link between capability-based perspectives and contingency perspectives. Prior IS literature has also recognized the importance of the fit between IT capabilities and environmental conditions (Lederer and Sethi 1996).

Finally, this research shows that different types or dimensions of flexibility are not necessarily positively associated with each other. In fact, we found a negative association between two types of ISDP flexibility. As a result, a set of important research questions arises. What is the optimal level of flexibility given a trade-off relationship? Is it possible to reduce the degree of the negative relationship and thus increase the degrees of all types/dimensions of flexibility? If so, how?

The present research has significant implications for practice. This research suggests that flexibility is generally beneficial, and the value of flexibility is particularly high when the project is under high complexity and uncertainty. According to this research, when project managers build flexibility into their project, they need to consider the project context to determine an appropriate level of flexibility.

In addition, as the two types of ISDP flexibility are negatively associated, ISDP managers need to make a trade-off decision as to the degree of each type of flexibility. As a result, a meta-flexibility (Volberda 1998), which is the capability to determine and build a right mix of different types/dimensions of flexibility, appears to be an important dynamic capability required by contemporary organizations in turbulent environments.
Conclusion

Limitations

The current research has limitations. While the sample size was fairly large (n = 505), this research used data obtained from a single informant for a given project. Triangulating the results by using multiple informants may increase the reliability and validity of informant reports because it minimizes potential informant bias. One of the possible approaches is to contact a relatively small number of users to examine if there is any significant difference compared to project managers’ responses.

Another limitation is that this study primarily focuses on realized flexibility rather than potential flexibility. Realized flexibility may or may not accurately reflect potential flexibility. Examination of potential flexibility has its own merits, and it may provide different or complementary insights and implications for theory and practice. Perhaps, one of the most difficult challenges in the study of potential flexibility is measuring the construct.

Directions for Future Research

Future research needs to address the aforementioned limitations of this research. In addition, we propose several directions for meaningful future research. First of all, future research needs to investigate how organizations build flexibility into their projects. Identifying project characteristics, methodologies, mechanisms, and approaches that would increase ISDP flexibility can provide useful insights for theory development and inform practitioners of best practices.

Second, it would be intriguing to examine the antecedents to and the effects of ISDP flexibility in different stages of software development lifecycle. Different stages of development lifecycle may require different degrees of flexibility. The time and cost required to actualize
flexibility in different stages may vary. Furthermore, the effect of ISDP flexibility in different stages on project performance may vary. Examining these issues can provide more specific and concrete implications for planning and managing ISDP flexibility.

Another direction for future research is examining flexibility at the level of portfolios of projects. Building excessive flexibility in one project may prevent the organization from maintaining appropriate levels of flexibility for other projects, thus decreasing the overall level of flexibility at the portfolio level. Investigating flexibility at the portfolio level would provide a big picture of how organizations allocate and manage resources across various projects.

Finally, tensions between flexibility and preservation need to be studied. Paradoxically, an ISDP team needs to build flexibility while maintaining focus and commitment to be successful (Volberda 1998). A lack of focus and commitment due to extreme flexibility may make the project team an order-taker drifting from one thing to another, thus failing to develop core project competencies in the long run. How to strike an optimal balance between commitment and flexibility is an important question to be addressed in future research.

References


Gefen, D. "It is Not Enough to be Responsive: The Role of Cooperative Intentions in MRP II Adoption," *The DATA BASE for Advances in Information Systems* (31:2), 2000, pp. 65-79.


Appendix A. ISDP Flexibility

(1) Measurement items

*Questions for FEXT items:*  
To what extent did the project actually incorporate changes in each of the following categories?  
(0 – 10 Likert scale: 0 indicating 0%, 10 indicating 100%)

*Questions for FEFF items:*  
How efficiently did the project incorporate changes in each of the following categories?  
(1-7 Likert scale: 1 very efficient, 7 very inefficient)

<table>
<thead>
<tr>
<th>Change categories</th>
<th>FEXT items</th>
<th>FEFF items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives of the system</td>
<td>FEXT1</td>
<td>--</td>
</tr>
<tr>
<td>System scope</td>
<td>FEXT2</td>
<td>FEFF1</td>
</tr>
<tr>
<td>Delivery date</td>
<td>FEXT3</td>
<td>FEFF2</td>
</tr>
<tr>
<td>System input data</td>
<td>FEXT4</td>
<td>FEFF3</td>
</tr>
<tr>
<td>System output data</td>
<td>FEXT5</td>
<td>FEFF4</td>
</tr>
<tr>
<td>Business rules/processes</td>
<td>FEXT6</td>
<td>FEFF5</td>
</tr>
<tr>
<td>Data structure</td>
<td>FEXT7</td>
<td>FEFF6</td>
</tr>
<tr>
<td>User interface</td>
<td>FEXT8</td>
<td>FEFF7</td>
</tr>
<tr>
<td>Programming tools/languages</td>
<td>FEXT9</td>
<td>FEFF8</td>
</tr>
<tr>
<td>IT architecture</td>
<td>FEXT10</td>
<td>FEFF9</td>
</tr>
<tr>
<td>Network/telecom environment</td>
<td>FEXT11</td>
<td>FEFF10</td>
</tr>
<tr>
<td>Other interfaced systems</td>
<td>FEXT12</td>
<td>FEFF11</td>
</tr>
<tr>
<td>IT infrastructure</td>
<td>FEXT13</td>
<td>FEFF12</td>
</tr>
</tbody>
</table>

(2) Assessment of unidimensionality

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of ind</th>
<th>$\chi^2$</th>
<th>df</th>
<th>GFI</th>
<th>AGFI</th>
<th>RMR</th>
<th>CFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEXTB</td>
<td>8</td>
<td>91.30</td>
<td>20</td>
<td>.96</td>
<td>.92</td>
<td>.026</td>
<td>.97</td>
</tr>
<tr>
<td>FEXTT</td>
<td>5</td>
<td>35.48</td>
<td>5</td>
<td>.97</td>
<td>.92</td>
<td>.022</td>
<td>.98</td>
</tr>
<tr>
<td>FEFFB</td>
<td>7</td>
<td>64.88</td>
<td>14</td>
<td>.97</td>
<td>.93</td>
<td>.034</td>
<td>.97</td>
</tr>
<tr>
<td>FEFFT</td>
<td>5</td>
<td>21.86</td>
<td>5</td>
<td>.98</td>
<td>.95</td>
<td>.024</td>
<td>.99</td>
</tr>
</tbody>
</table>

(3) Assessment of discriminant validity

<table>
<thead>
<tr>
<th>Description</th>
<th>ML Estimate $\hat{\varnothing}$</th>
<th>$t$-value</th>
<th>$\chi^2$ Statistic</th>
<th>$\chi^2$ Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Constrained model (df)</td>
<td>Unconstrained model (df)</td>
</tr>
<tr>
<td>FEXTB with FEXTT</td>
<td>0.70</td>
<td>10.42**</td>
<td>234.44(65)</td>
<td>217.17(64)</td>
</tr>
<tr>
<td>FEFFB with FEFFT</td>
<td>0.59</td>
<td>8.14**</td>
<td>194.60(54)</td>
<td>187.58(53)</td>
</tr>
</tbody>
</table>

* p < .05  ** p < .01
Appendix B. ISDP Complexity

(1) Measurement items of ISDP complexity

**Structural organizational complexity (SORG)**
ISDPC1. The project personnel did not have required knowledge/skills
ISDPC2. The project manager did not have direct control over project resources
ISDPC3. There was no sufficient commitment/support from the top management
ISDPC4. There was no sufficient/appropriate staffing for the project
ISDPC5. Business users provided insufficient support and involvement

**Structural IT complexity (SIT)**
ISDPC6. The project involved multiple external contractors and vendors
ISDPC7. The system involved real-time data processing
ISDPC8. The project involved multiple software environments
ISDPC9. The project involved coordinating multiple user units
ISDPC10. The project team was cross-functional
ISDPC11. The project involved multiple technology platforms
ISDPC12. The project involved a lot of integration with other systems

**Dynamic organizational complexity (DORG)**
ISDPC13. Implementing the project caused changes in the users' business processes
ISDPC14. Implementing the project caused changes in the users' organizational structure
ISDPC15. The end-users' business processes changed rapidly
ISDPC16. The end-users' organizational structure changed rapidly
ISDPC17. The end-users' information needs changed rapidly

**Dynamic IT complexity (DIT)**
ISDPC18. Software development tools that the project depended on changed rapidly
ISDPC19. IT architecture that the project depended on changed rapidly
ISDPC20. IT infrastructure that the project depended on changed rapidly

(2) Assessment of unidimensionality

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of ind.</th>
<th>$\chi^2$</th>
<th>df</th>
<th>GFI</th>
<th>AGFI</th>
<th>RMR</th>
<th>CFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SORG</td>
<td>5</td>
<td>15.21</td>
<td>5</td>
<td>0.99</td>
<td>0.96</td>
<td>0.030</td>
<td>0.98</td>
</tr>
<tr>
<td>SIT</td>
<td>7</td>
<td>125.90</td>
<td>14</td>
<td>0.93</td>
<td>0.87</td>
<td>0.063</td>
<td>0.88</td>
</tr>
<tr>
<td>DORG</td>
<td>5</td>
<td>87.70</td>
<td>5</td>
<td>0.93</td>
<td>0.80</td>
<td>0.062</td>
<td>0.88</td>
</tr>
<tr>
<td>DIT</td>
<td>3</td>
<td>33.09</td>
<td>19</td>
<td>0.98</td>
<td>0.97</td>
<td>0.034</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Note: (a) This model is saturated because the number of indicators is 3. Therefore, fit indices are not available. Fit indices for this factor resulted from a two-factor model including DIT and SORG.
(3) Assessment of discriminant validity

<table>
<thead>
<tr>
<th>Description</th>
<th>$\chi^2$ Statistic</th>
<th>ML Estimate $\hat{\theta}$</th>
<th>$t$-value</th>
<th>Constrained model (df)</th>
<th>Unconstrained model (df)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SORG with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIT</td>
<td>0.04</td>
<td>0.79</td>
<td></td>
<td>276.01 (54)</td>
<td>208.48 (53)</td>
<td>67.53**</td>
</tr>
<tr>
<td>DORG</td>
<td>0.20</td>
<td>3.23**</td>
<td></td>
<td>193.55 (35)</td>
<td>132.75 (34)</td>
<td>60.80**</td>
</tr>
<tr>
<td>DIT</td>
<td>0.30</td>
<td>4.98**</td>
<td></td>
<td>63.03 (20)</td>
<td>33.09 (19)</td>
<td>29.94**</td>
</tr>
<tr>
<td>DIT with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DORG</td>
<td>0.22</td>
<td>3.64**</td>
<td></td>
<td>361.06 (54)</td>
<td>309.69 (53)</td>
<td>51.37**</td>
</tr>
<tr>
<td>DIT</td>
<td>0.25</td>
<td>4.35**</td>
<td></td>
<td>201.69 (35)</td>
<td>167.95 (34)</td>
<td>33.74**</td>
</tr>
<tr>
<td>DORG with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIT</td>
<td>0.28</td>
<td>5.36**</td>
<td></td>
<td>161.51 (20)</td>
<td>116.03 (19)</td>
<td>45.48**</td>
</tr>
</tbody>
</table>

* $p < .05$  ** $p < .01$

Appendix C. IS Performance

(1) Measurement items

**Systems functionality (FUNC)**
- PERF1. The system delivered by the project achieved its functional goals
- PERF2. The capabilities of the system fit end-user needs
- PERF3. The system met technical requirements

**User satisfaction (USAT)**
- PERF4. The system provided sufficient information for end-users
- PERF5. The output of the system was presented in a useful format
- PERF6. The system was easy to use
- PERF7. The system provided useful information for end-users

(2) Assessment of unidimensionality and convergent validity

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of ind.</th>
<th>$\chi^2$</th>
<th>df</th>
<th>GFI</th>
<th>AGFI</th>
<th>RMR</th>
<th>CFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNC</td>
<td>3</td>
<td>74.02</td>
<td>13</td>
<td>0.96</td>
<td>0.91</td>
<td>0.030</td>
<td>0.98</td>
</tr>
<tr>
<td>USAT</td>
<td>4</td>
<td>8.81</td>
<td>2</td>
<td>0.99</td>
<td>0.96</td>
<td>0.015</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Note: (a) This model is saturated because the number of indicators is 3. Therefore, fit indices are not available. Fit indices for this factor resulted from a two-factor model including FUNC and USAT.

(3) Assessment of discriminant validity

<table>
<thead>
<tr>
<th>Description</th>
<th>$\chi^2$ Statistic</th>
<th>ML Estimate $\hat{\theta}$</th>
<th>$t$-value</th>
<th>Constrained model (df)</th>
<th>Unconstrained model (df)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUNC with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USAT</td>
<td>0.86</td>
<td>12.20**</td>
<td></td>
<td>78.34(14)</td>
<td>74.02(13)</td>
<td>4.32*</td>
</tr>
</tbody>
</table>

* $p < .05$  ** $p < .01$
Appendix D. Covariance Matrix of the Total Sample (continued)

<table>
<thead>
<tr>
<th>FEXT1</th>
<th>3.22</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEXT2</td>
<td>2.16 3.01</td>
</tr>
<tr>
<td>FEXT3</td>
<td>1.61 1.65 3.90</td>
</tr>
<tr>
<td>FEXT4</td>
<td>2.20 2.06 1.62 3.62</td>
</tr>
<tr>
<td>FEXT5</td>
<td>2.18 2.06 1.64 2.71 3.28</td>
</tr>
<tr>
<td>FEXT6</td>
<td>2.21 2.13 1.50 2.46 2.51 3.46</td>
</tr>
<tr>
<td>FEXT7</td>
<td>1.96 1.96 1.67 2.40 2.18 2.35 3.64</td>
</tr>
<tr>
<td>FEXT8</td>
<td>2.08 1.96 1.67 2.17 2.24 2.13 2.05 3.43</td>
</tr>
<tr>
<td>FEXT9</td>
<td>1.69 1.33 1.24 1.72 1.63 1.46 1.60 1.73 3.79</td>
</tr>
<tr>
<td>FEXT10</td>
<td>1.80 1.36 1.19 1.72 1.72 1.63 1.70 1.69 2.69 3.79</td>
</tr>
<tr>
<td>FEXT11</td>
<td>1.61 1.37 1.33 1.76 1.75 1.59 1.77 1.67 2.45 2.80 3.82</td>
</tr>
<tr>
<td>FEXT12</td>
<td>1.90 1.53 1.48 2.00 1.92 1.93 1.89 1.85 2.01 2.30 2.43 3.81</td>
</tr>
<tr>
<td>FEXT13</td>
<td>1.79 1.52 1.25 1.82 1.81 1.71 1.91 1.80 2.38 2.93 2.77 2.57 3.65</td>
</tr>
<tr>
<td>FEFF1</td>
<td>-0.91 -1.19 -0.37 -0.91 -0.92 -1.09 -0.96 -0.83 -0.75 -0.84 -0.69 -0.82 -0.86 3.56</td>
</tr>
<tr>
<td>FEFF2</td>
<td>-0.70 -0.74 -0.78 -0.80 -0.82 -0.75 -0.82 -0.89 -0.83 -1.00 -0.98 -0.97 -1.07 1.88 3.84</td>
</tr>
<tr>
<td>FEFF3</td>
<td>-0.68 -0.79 -0.45 -1.08 -0.87 -1.07 -0.96 -0.65 -0.61 -0.73 -0.89 -0.99 -0.98 1.74 1.39 3.20</td>
</tr>
<tr>
<td>FEFF4</td>
<td>-0.82 -0.86 -0.50 -1.04 -1.11 -1.22 -0.94 -0.80 -0.92 -0.93 -1.02 -1.02 -1.04 1.79 1.52 2.16 3.14</td>
</tr>
<tr>
<td>FEFF5</td>
<td>-0.78 -0.94 -0.43 -1.06 -1.03 -1.36 -1.05 -0.72 -0.57 -0.72 -0.71 -0.90 -1.00 1.87 1.48 1.94 2.05</td>
</tr>
<tr>
<td>FEFF6</td>
<td>-0.61 -0.74 -0.58 -0.81 -0.71 -0.88 -1.23 -0.65 -0.76 -0.80 -0.74 -0.79 -0.95 1.66 1.35 1.73 1.58</td>
</tr>
<tr>
<td>FEFF7</td>
<td>-0.75 -0.87 -0.60 -0.89 -0.90 -0.79 -0.74 -1.06 -0.91 -0.78 -0.69 -0.65 -0.76 1.55 1.45 1.43 1.74</td>
</tr>
<tr>
<td>FEFF8</td>
<td>-0.37 -0.37 -0.20 -0.39 -0.36 -0.31 -0.47 -0.32 -1.10 -0.72 -0.50 -0.39 -0.70 0.91 0.87 0.68 0.88</td>
</tr>
<tr>
<td>FEFF9</td>
<td>-0.61 -0.51 -0.45 -0.67 -0.43 -0.48 -0.68 -0.61 -0.94 -1.23 -1.03 -0.71 -1.17 1.09 1.14 0.83 0.89</td>
</tr>
<tr>
<td>FEFF10</td>
<td>-0.35 -0.49 -0.56 -0.51 -0.46 -0.45 -0.76 -0.48 -0.67 -0.83 -1.35 -0.67 -0.93 0.90 0.89 0.83 0.86</td>
</tr>
<tr>
<td>FEFF11</td>
<td>-0.81 -0.82 -0.52 -0.77 -0.68 -0.78 -0.85 -0.62 -0.76 -0.95 -0.96 -1.44 -1.06 1.24 1.12 1.24 1.16</td>
</tr>
<tr>
<td>FEFF12</td>
<td>-0.66 -0.62 -0.47 -0.71 -0.55 -0.56 -0.74 -0.66 -1.00 -1.15 -1.07 -0.87 -1.33 1.19 1.11 0.97 1.03</td>
</tr>
<tr>
<td>PERF1</td>
<td>0.23 0.16 0.37 0.33 0.22 0.31 0.11 0.39 -0.04 -0.09 -0.04 0.19 -0.10 0.65 0.41 0.32 0.31</td>
</tr>
<tr>
<td>PERF2</td>
<td>0.24 0.20 0.42 0.35 0.28 0.38 0.32 0.42 0.13 0.07 0.20 0.22 0.04 0.57 0.41 0.25 0.28</td>
</tr>
<tr>
<td>PERF3</td>
<td>0.36 0.18 0.49 0.31 0.36 0.35 0.17 0.46 0.16 0.16 0.22 0.28 0.10 0.54 0.23 0.25 0.32</td>
</tr>
<tr>
<td>PERF4</td>
<td>0.24 0.22 0.28 0.26 0.31 0.31 0.24 0.42 0.09 0.14 0.17 0.16 0.04 0.51 0.36 0.30 0.36</td>
</tr>
<tr>
<td>PERF5</td>
<td>0.23 0.14 0.33 0.17 0.24 0.25 0.14 0.50 0.12 0.11 0.12 0.08 -0.04 0.38 0.24 0.32 0.32</td>
</tr>
<tr>
<td>PERF6</td>
<td>0.19 0.18 0.45 0.25 0.22 0.29 0.27 0.62 0.20 0.19 0.31 0.27 0.02 0.45 0.30 0.35 0.40</td>
</tr>
<tr>
<td>PERF7</td>
<td>0.20 0.23 0.31 0.33 0.32 0.38 0.34 0.43 0.19 0.19 0.26 0.15 0.03 0.38 0.34 0.22 0.23</td>
</tr>
</tbody>
</table>
Appendix D. Covariance Matrix of the Total Sample

<table>
<thead>
<tr>
<th></th>
<th>FEFF5</th>
<th>3.42</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEFF6</td>
<td>1.68</td>
<td>2.95</td>
</tr>
<tr>
<td>FEFF7</td>
<td>1.46</td>
<td>1.50</td>
</tr>
<tr>
<td>FEFF8</td>
<td>0.91</td>
<td>1.01</td>
</tr>
<tr>
<td>FEFF9</td>
<td>0.91</td>
<td>1.09</td>
</tr>
<tr>
<td>FEFF10</td>
<td>0.87</td>
<td>0.96</td>
</tr>
<tr>
<td>FEFF11</td>
<td>1.16</td>
<td>1.24</td>
</tr>
<tr>
<td>FEFF12</td>
<td>0.90</td>
<td>1.18</td>
</tr>
<tr>
<td>PERF1</td>
<td>0.30</td>
<td>0.32</td>
</tr>
<tr>
<td>PERF2</td>
<td>0.28</td>
<td>0.30</td>
</tr>
<tr>
<td>PERF3</td>
<td>0.28</td>
<td>0.43</td>
</tr>
<tr>
<td>PERF4</td>
<td>0.28</td>
<td>0.38</td>
</tr>
<tr>
<td>PERF5</td>
<td>0.16</td>
<td>0.36</td>
</tr>
<tr>
<td>PERF6</td>
<td>0.31</td>
<td>0.38</td>
</tr>
<tr>
<td>PERF7</td>
<td>0.12</td>
<td>0.37</td>
</tr>
</tbody>
</table>