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Measuring Information Systems Agility: Construct Definition and Scale Development

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ABSTRACT

Organizational agility has been a touted by both researchers and practitioners as a key success factor in navigating turbulent business environments. With a heavy reliance on computer systems by many organizations, information systems agility has become an important contributor to organizational agility. The purpose of this paper is to investigate previous attempts at defining the IS agility construct and synthesize the previous work into a single, comprehensive definition of IS agility. With a complete definition of IS agility compiled, steps will be outlined for developing a reliable scale for measuring IS agility within organizations.

Keywords

Information systems agility, IS architecture, IS personnel, IS processes

INTRODUCTION

The ever-changing business environment requires organizations to react quickly and easily to business challenges that arise. The terms agility, flexibility, and dynamic capabilities have all been used to describe this phenomenon and researchers have approached the topic from numerous viewpoints. Specific to information systems literature, agility has been studied as an independent variable (Sambamurthy, Bharadwaj and Grover, 2003; Gebauer & Schober, 2006), a dependent variable (Fink & Neumann, 1997; Wang, Ju, Jiang and Klein, 2008), or in an exploratory manner (Byrd & Turner, 2000; Duncan, 1995). Most of the previous literature focuses on individual components of IS agility and does not attempt to capture the full domain of the construct. Additionally, there does not appear to be a widely utilized measurement tool for evaluating IS agility within organizations.

This paper aims to address these issues by providing several contributions. First a review of the previous literature will be presented. By synthesizing concepts from previous studies, a holistic view of IS agility will be formed and the multi-dimensional construct of IS agility will be defined. Finally, a scale will be developed to measure IS agility within organizations.

BACKGROUND OF THE IS AGILITY CONSTRUCT

After a thorough review of previous literature, it was determined that research has focused on three primary dimensions of IS agility: agility of the IT artifact, of the processes supporting the IT artifact, and of the people involved in the processes.

When investigating the agility of the IT artifact, a clear focus on the architecture and infrastructure is necessary. Studies have defined this infrastructure as a set of shared, tangible IT resources that form a foundation to enable present and future business applications (Duncan, 1995) or as "the ability of the IT unit to provide extensive firm-wide IT infrastructure services that support the organization's business IS processes" (Fink & Neumann, 2007). Broadbent, Weill and Neo (1999) list hardware platforms, base software platforms, communications technology, middleware and other capability that provides shared services to a range of applications and common handling mechanisms for different data types as the key components to technical infrastructure. Weill, Subramani and Broadbent (2002) describe channel management, security and risk management, communications, data management, application infrastructure, and IT facilities management as key components to the infrastructure. Other studies zero in on individual components of technical infrastructure such as application architecture (Allen & Boynton, 1991), software characteristics (Gebauer & Schober, 2006), or the connectivity of IT components (Sambamurthy et al., 2003). Collectively, this dimension of agility will herein be referred to as "technical infrastructure agility".

The processes by which information systems are supported and changed also represent a key component to IS agility. There is a direct linkage between IS processes in place and the technical infrastructure capabilities of the organization (Fink & Neumann, 2007). Goodhue, Chen, Boudreau, Davis and Cochran (2009) identify the processes by which organizations apply changes to their ERP and non-ERP systems to achieve agility. Other studies have investigated the impact of change management procedures and management review of IS development processes on the flexibility of an IS (Wang et al., 2008) and defined the importance of IT management services and IT architecture and standards services in providing a set of

processes by which IS agility can be attained (Weill et al., 2002). We combine this previous work into the "IS process agility" dimension of agility in this paper.

Although some studies do not specifically focus on the human characteristics that influence agility, it is implied that the technical infrastructure and IS processes could not exist without human intervention. For this reason, it is imperative to include behavioral aspects in the study of IS agility. Gebauer & Schober (2006) include a variety of skills and attitudes of the IT staff as a key component in IT flexibility. Both technical knowledge of the IS being supported as well as a deep understanding of the business are needed by IT staff members to maximize flexibility (Duncan, 1995). IT education and training, such that users, support personnel, and management have the knowledge and skills necessary to extract value from the system, also promote greater agility (Weill et al., 2002). These studies, coupled with the implied involvement of human beings from other studies represent what is referred to as "human characteristics" in this study.

DEVELOPMENT OF THE IS AGILITY CONSTRUCT

A review of the literature has resulted in the identification of three dimensions of IS agility: technical infrastructure agility, IS process agility, and human characteristics. Based on the previous work cited above, we can define IS agility as the ability of IT artifacts, of information stored within those artifacts, and of the underlying processes that support and maintain the artifacts and information to quickly adapt to changing business needs. The three dimensions of this construct are broadly defined and are multi-dimensional in nature. Therefore, it is necessary to break each down into several first-order dimensions. Table 1 defines each first and second order dimension and the theoretical base for each definition. Further discussion of the dimensions will follow.

First and Second Order Dimensions	Definition	Support from Literature
Technical Infrastructure Agility	Sets of technical component configurations and architectures that enable rapid and facilitated changes to information systems	
Hardware Platform Agility	The ability to move application and system components across platforms and physical infrastructure such as servers and storage devices	Allen & Boynton, 1991; Byrd & Turner, 2000; Duncan, 1995; Fink & Neumann, 2007; Gebauer & Schober, 2006; Weill et al., 2002
Network Inter-Connectedness	The connectivity between IS components and the security and dependability of those connections	Byrd & Turner, 2000; Duncan, 1995; Fink & Neumann, 2007; Gebauer & Schober, 2006; Sambamurthy et al., 2003 ; Weill et al., 2002
Application Agility	The ability to quickly add, modify, or remove software components from the information system	Allen & Boynton, 1991; Byrd & Turner, 2000; Duncan, 1995; Fink & Neumann, 2007; Gebauer & Schober, 2006; Goodhue et al., 2009; Lee, Siau and Hong 2003 ; Sambamurthy et al., 2003 ; Weill et al., 2002
Information Agility	The ability to freely retrieve and share data between components of the IS and to users	Byrd & Turner, 2000; Duncan, 1995; Fink & Neumann, 2007; Gebauer & Schober, 2006; Weill et al., 2002
IS Process Agility	A set of business processes that enable rapid and facilitated changes to information systems	
Maintenance Process Agility	The ability to quickly and easily perform system tasks to keep it in proper working order	Lientz, 1978; Boynton, Zmud and Jacobs, 1994
Planning Process Agility	The ability to quickly and easily evaluate and prioritize proposed system changes to ready them for development	Borjesson, Martinsson and Timmeras, 2006 ; Boynton et al., 1994 ; Byrd & Turner, 2000; Duncan, 1995; Fink & Neumann, 2007 Gebauer & Schober, 2006; Goodhue et al., 2009 ; Lee et al., 2003 ; Sambamurthy et al., 2003 ; Weill et al., 2002
Development	The ability to quickly and easily implement	Borjesson et al., 2006 ; Boynton et

Process Agility	new functionality or modify existing functionality in an information system.	al., 1994 ; Goodhue et al., 2009 ; Wang et al., 2008 ; Weill et al., 2002
Monitoring & Assessment Process Agility	The ability to gather information and performance metrics in a rapid and efficient manner to evaluate system effectiveness and agility	Boynton et al., 1994
Human Characteristics	Sets of skills possessed by organization members that promotes quick and easy changes to information systems	
Behavioral Skills	The interpersonal skills and social capital of IS personnel	Fink & Neumann, 2007; Davis, 2009
Business Skills	The management skills and business process knowledge possessed by individuals within an organization	Borjesson et al., 2006 ; Byrd & Turner, 2000 ; Duncan, 1995; Fink & Neumann, 2007; Gebauer & Schober, 2006; Weill et al., 2002
Technical Skills	The breadth and depth of knowledge of system architecture, programming, operating systems, and all other technical components supporting an IS of members in the IS department	Borjesson et al., 2006 ; Byrd & Turner, 2000 ; Duncan, 1995; Fink & Neumann, 2007; Gebauer & Schober, 2006; Weill et al., 2002

Table 1: Definitions of IS Agility First Order Dimensions

The first and second order dimensions that comprise the IS agility construct are graphically depicted below in Figure 1.

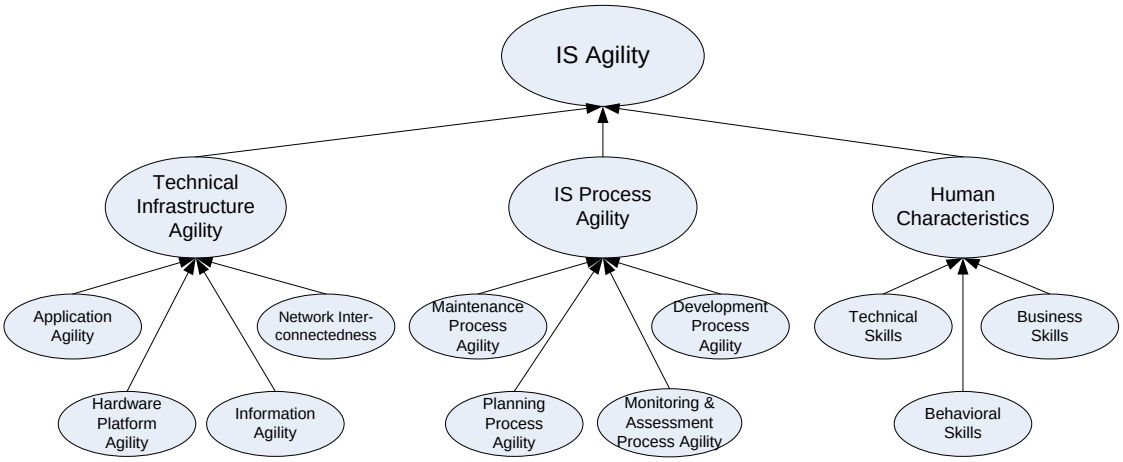

Figure 1: Multi-Dimensional Construct of IS Agility

FIRST-ORDER DIMENSIONS OF THE TECHNICAL INFRASTRUCTURE AGILITY DIMENSION

Application agility is derived predominantly from application functionality (Byrd & Turner, 2000) and IT-dependent system agility (Fink & Neumann, 2007). *Network Inter-connectedness* is akin to the notion of connectivity presented by Duncan (1995) and Byrd & Turner (2000) and the communication services cluster described by Weill et al. (2002). In essence, network inter-connectedness encompasses the connectivity between IS components and the security and dependability of those connections. *Hardware platform agility* aligns most closely with Weill et al.'s (2002) IT-facilities management services cluster and Byrd & Turner's (2000) IT compatibility construct. Finally, *information agility* aligns with data transparency (Byrd & Turner, 2000), Weill et al.'s (2002) data management cluster, and IT-dependent information agility (Fink & Neumann, 2007).

FIRST-ORDER DIMENSIONS OF THE IS PROCESS AGILITY DIMENSION

Fink & Neumann's description of IT-dependent strategic agility and Byrd & Turner's (2000) technology management construct have similar qualities that relate to *planning capabilities*. An example of poor planning process agility is an organization that has a long backlog of system development requests such that the evaluation of such requests cannot be completed in a timely manner (Byrd & Turner, 2000). Agile development practices, as discussed by Borjesson et al. (2006), and the change management procedures investigated by Wang et al. (2008) both relate to *development process agility*.

Lientz, Swanson, Tompkins and Morgan (1978) focus predominantly on software maintenance procedures which presents a third process categorization: *maintenance process agility*. One example of high maintenance process agility is an organization that utilizes a weekly review and installation process for recently released system patches. Conversely, an organization which has a rigid process for installing system patches once per year would exhibit considerably lower levels of maintenance process agility. .

To ensure content validity of the IS process agility dimension, a further review of literature specific to IS processes was conducted. The Control Objectives for Information and Related Technologies (COBIT) framework (version 4.1) was used as a starting point for analysis. Although not based on traditional academic rigor, the COBIT framework has been developed and enhanced by practitioners over the past 13 years. This framework was referenced as it aims to define all IS processes that organizations typically employ. COBIT provides four dimensions of IS processes: plan and organize, acquire and implement, deliver and support, and monitor and evaluate. The three dimensions emerging from the review of IS agility literature cover the first three dimensions of COBIT, but the fourth, monitor and evaluate, is not fully addressed. To further the content analysis, the 11 groups of IS processes presented by Boynton et al. (1995) were also reviewed. With the exception of administrative services, all processes were determined to fit into the dimensions previously mentioned or into the COBIT dimensions. Administrative services, comprised of financial administration and staff performance, are activities that could be classified as overhead and not directly related to IS, so this group of processes will not be represented in this paper.

Since the previous IS agility literature fails to cover the monitoring and evaluation processes documented in COBIT and Boynton et al.'s process groups, the addition of a fourth IS process agility dimension must be added to our model. Therefore, "*monitoring and assessment process agility*" was included in our definition of IS agility. Those organizations that provide daily or weekly performance metrics and dashboards regarding the success of system changes and implementations would be considered to have higher monitoring and assessment agility than those organizations that do not provide such information to management or do so on a quarterly or yearly basis.

FIRST-ORDER DIMENSIONS OF THE HUMAN CHARACTERISTICS DIMENSION

Human characteristics are represented in a number of prior studies and the delineation between technical skills and business skills are often highlighted. Duncan (1995) specifically demarcates between the two types of skill, as do Byrd & Turner (2000). Fink & Neumann (2007) also include behavioral capabilities, such as interpersonal skills, in addition to business and technical knowledge in their study. Davis (2009) investigated the social capital between members of the IS group and other business units and the impact of this social capital on agility. Based on these previous studies, three dimensions within the human characteristics dimension emerge: behavioral skills, business skills, and technical skills.

It should be noted that for all first-order dimensions in the human characteristics dimension, it is of paramount importance to evaluate skills at the organizational, rather than individual level. Individuals with a very deep understanding of a single technical component, such as the IBM DB2 database platform, may not contribute significantly to an information system's agility as the knowledge and experience may create a competency trap. Evaluation of behavioral characteristics must be performed at the organizational level to ensure a complete picture of the skills possessed by the collective group is obtained. When assessed at the organizational level, behavioral, business, and technical skills should encompass a broad range of skills/competencies as well as a deep-rooted understanding or display of such skills and competencies.

As mentioned in the previous discussion, numerous studies have investigated individual components of IS agility. This paper attempts to synthesize all previous work in the area of agility to present a complete picture of the dimensions that form overall IS agility. Table 2 summarizes how previous literature addresses the dimensions developed in this paper and highlights the fact that no individual study to date has addressed all of the dimensions proposed in this research.

	Technical Infrastructure Agility				**IS Process Agility**				**Human Characteristics**		
Study	Hardware Platform Agility	Network Inter-connectedness	Application Agility	Information Agility	Planning Process Agility	Maintenance Process Agility	Development Process Agility	Monitoring & Assessment Process Agility	Behavioral Skills	Business Skills	Technical Skills
Allen & Boynton, 1991	X	X	X	X							
Borjesson et al., 2006					X		X				
Boynton et al., 1994					X	X	X	X			
Byrd & Turner, 2000	X	X	X	X	X				X	X	X

Davis, 2009					X		X		X	X	X
Duncan, 1995	X	X	X	X	X					X	X
Fink & Neumann, 2007	X	X		X					X	X	X
Gebauer & Schober, 2006	X	X	X	X						X	X
Goodhue et al., 2009					X		X				
Lee et al., 2003	X	X	X		X		X				
Lientz, 1978						X					
Sambamurthy et al., 2003	X	X	X	X	X						
Wang et al., 2008					X		X				
Weill et al., 2002	X	X	X	X	X				X		X

Table 2 – Prior Research Coverage of First-Order Dimensions

SCALE DEVELOPMENT FOR IS AGILITY

Item Generation

With the three second-order dimensions and 11 first-order dimensions defined, a content analysis of previous measurement tools was conducted to generate a preliminary pool of items. For each study that employed a survey instrument, the individual items were reviewed and sorted into the first-order dimension that they were believed to belong to. From the five studies for which survey instruments were utilized, a total of 118 items were compiled. To supplement the items identified from previous studies, additional items were drafted by the author and a panel of experts who are currently practitioners in the IS field. To ensure adequate coverage of all content domains, a minimum of 20 items per first-order dimension were generated (Netemeyer, Bearden and Sharma, 2003). This resulted in a total of 225 items generated across the eleven dimensions.

Scale Validation

The remaining steps in validating and finalizing this scale are yet to be performed however a brief overview of the intended procedures is provided in this paper (Netermeyer et al 2003; Churchill, 1979). To qualitatively assess construct validity, the initial pool of items will go through several rounds of item sorting. Initial item sorting will be performed by a panel of experts with no a priori definitions of the dimensions. Secondary sorting will consist of experts sorting items into the dimensions as defined by the researcher. Feedback will be solicited from the experts to rephrase items that are ambiguous or unclear and recommendations to drop items from the pool will be considered.

Upon completion of item sorting, the pool of items should demonstrate reasonable levels of content, convergent, discriminant validity. A pre-test will then be conducted using a convenience sample of respondents. The pre-test will consist of respondents rating each of the items on a 7 point Likert-type scale. Open-ended questions will ask respondents to comment on survey length, item wording, and any recommendations for improvement to the measurement instrument. The results of the pre-test will be reviewed by the researcher to identify whether additional items should be removed or reworded. Another qualitative assessment of convergent and discriminant validity will be performed on the results of the pre-test.

A pilot-test will then be conducted with a large enough sample size to allow for quantitative factor analysis of the results. Respondents will again be asked to rate each of the items on a 7 point Likert-type scale and provide feedback on survey length, item wording, and overall survey quality. The results of the pilot test will be analyzed using principle axis factoring to assess dimensionality, convergent, and discriminant validity. Items will be deleted and reworded where appropriate. Upon completion of the pilot test, it is the aim of the researcher to have a survey instrument of manageable length and has strong psychometric properties.

To finalize the scale, a full-scale field test will be conducted. The sampling frame will be individuals in management positions inside their respective IS departments. The field test will require respondents to rate all items in the scale on a 7 point Likert-type scale. Demographic information will also be collected from respondents to aid in assessing generalizability and testing for non-response bias. Convergent validity, discriminant validity, and reliability will all be assessed via confirmatory factor analysis to verify the psychometric properties of the scale and nomological validity will be assessed by embedding the scale in a nomological network of known antecedents and consequents.

CONCLUSION

This paper aims to define the domain of the IS agility construct by reviewing and synthesizing previous work in this field. The dimensions described above help us to understand the full spectrum of IS agility and can enable researchers to better assess the characteristics of agile information systems in future work. Upon completion of the validation and finalization

procedures, the scale developed through this work can be used by researchers to address numerous research questions relating to information system agility. Agility will continue to be an important topic for researchers and practitioners alike and it is the intention of this researcher to provide a reliable instrument for measuring this construct.

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