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ICT-RELATED INTANGIBLES AND ORGANIZATIONAL INNOVATION: INDICATORS FOR IMPROVING CONNECTEDNESS AND FLEXIBILITY

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Abstract: *In this paper we address the role of ICT-related intangible assets in organizational innovation. We focus on two important innovation enablers: first, connectedness, the ability of individuals to create and maintain connections to each other; and second, organizational flexibility to adapt to changing needs. For connectedness and flexibility, an agile ICT infrastructure and information management services are needed. Through a Delphi study, we identified several factors hindering organizational innovation, and formulated a set of indicators and related metrics for improvement. We conclude that it is necessary to consider ICT-related factors when organizations pursue improving their innovativeness. However, ICT solutions do not lead to organizational innovativeness independent of other organizational factors and people. If the organization is well-functioning, suitable ICT solutions can provide important added value for its innovation activities.*

Keywords: *organizational innovation, ICT solutions, information management, intangibles, connectedness, flexibility, improvement.*

INTRODUCTION

The development, adoption, and implementation of innovations are critical determinants of organizational competitiveness and effectiveness (Baregheh, Rowley, & Sambrook, 2009). In contemporary organizations, information and communication technologies (ICTs) pervade every aspect of an organization's value chain, creating a vast electronic network of interconnected applications and data (Kohli & Melville, 2009). Not only do an organization's daily operations

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rely on ICTs, but the innovation processes do as well, which makes ICT-related factors important as enablers or hindrances of organizational innovation.

Two key issues enable innovation. First, innovation relates to the ability of individuals to create and maintain connections to each other informally (Jansen, van den Bosch, & Volbera, 2006). Second, innovation is associated with change, which means that business processes need to be flexible and able to adapt to changing needs in and beyond an organization (MacKinnon, Grant, & Cray, 2008). The demand for connectedness and flexibility set challenges for the organization's ICT infrastructure, as well as for the services provided by the information management function. To be able to make proper decisions regarding ICT-related issues, organizations need knowledge of the factors that enable or hinder connectedness and flexibility.

Guidelines for an organization's ICT infrastructure and ICT services are set in the enterprise architecture. It establishes an organization-wide road map to achieve the organization's mission through optimal performance of its core business processes within an efficient ICT environment (Institute for Enterprise Architecture Developments, 2007). It provides important added value for the organization and enables more effective strategy making and better knowledge of the effects of various decisions by high-level management (Varveris & Harrison, 2005). To support innovation processes effectively, the enterprise architecture should incorporate connectedness and flexibility as important issues in ICT-related decision making.

In this study, we identified intangible ICT-related factors that enable connectedness and flexibility in organizations, as well as metrics for their assessment. The study is based on qualitative data gathered using the Delphi method (Linstone & Turoff, 1975). A group of panelists, primarily Finnish ICT and innovation experts within academia and industry, were asked to identify ICT-related factors that hinder flexibility and connectedness in organizations and which thereby impede innovation processes. Various statements about the identified factors were formulated from the data and given to the panelists for further comment, refinement, and corrections. A list of indicators was formulated based on the identified factors, and related metrics were identified from the gathered data and relevant literature.

This paper is organized as follows. First, we provide a literature review on issues related to innovation and ICT. We then describe the research setting and methodology. After that, we present the indicators and metrics identified as the result of the study. Finally, we discuss some conclusions from the study.

A REVIEW OF THE LITERATURE

In this section, we discuss various issues related to innovation and ICTs. These issues include innovation processes, connectedness and flexibility in an innovation process, and ICTs in innovation processes.

Innovation Processes

Baregheh et al. (2009) defined innovation as "the multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace" (p. 1334). This definition emphasizes that the innovation activity concerns not only the process of inventing but also extends idea inventing into the implementation and commercialization of the innovation.

Innovation has specific characteristics, as presented by the Commission of the European Communities (2009). Innovation concerns successfully exploiting new ideas and transforming them into economic value and sustainable competitive advantage. Innovation, then, is something new for the company but not necessarily for the field of markets; it must be beneficial to customers and customers must be willing to pay for it. Innovations help organizations diversify and improve the quality of their product and service selection, and improve processes. Innovation activities can be promoted by creating an inventive and creative working environment and investing in R&D activities, networking, and information technology. Furthermore, as Hautamäki (2010) indicated, innovation always occurs within local and global innovation ecosystems, that is, an environment that contains other companies, research institutes, funders, labor, markets, common legislation, and so forth.

Innovations may concern technology or social and organizational arrangements (Edström, Lind, & Ljungberg, 2004). They can be clever, insightful, and useful ideas from anyone in an organization, or they can arise from organized innovation activities, with resources allocated for research and development to create innovations (Godin, 2004). The innovation process may be organized in different ways. An organization may invest in the necessary research and development itself (a closed innovation process) or acquire the innovation from other organizations, for example, in the form of licenses or technologies (open innovation process; Chesbrough, 2003; Hautamäki, 2010). The innovation may also be developed in a networked community for exclusive use of the participants (private-collective innovation process) or to be used freely (common innovation process; Hautamäki, 2010). Another way is to gather the ideas from customers or users who want to improve products to better meet their needs (customer-driven innovation process; Hautamäki, 2010).

Moreover, innovations can be classified in various ways. Explorative innovations open up completely new ways of thinking and actions, while exploitative innovations refine and improve already existing explorative innovations (Jansen et al., 2006; March, 1991). Explorative innovations can create new fields of knowledge, breed new technology, open new markets, enable novel ways of doing things, and spur renewal of organizational structures and practices (Jansen et al., 2006). However, returns from exploration are systematically less certain, more remote in time, and organizationally more distant from the locus of action and adaptation (March, 1991). Innovations also can be distinguished by how they affect design structures. Modular innovations change the core design components, whereas architectural innovations change their interrelationships (Henderson & Clark, 1990). Autonomous modular innovation can be done without modifying other components, whereas systemic innovation requires significant modifications to other related components (Teece, 1996).

Various models of the innovation process are presented in the literature and, typically, they include three to six stages. For example, Chesbrough (2003) identified three stages: research, development, and marketing. Baregheh et al. (2009) proposed five stages: creation, generation, implementation, development, and adoption. Siebra, Filho, Silva, and Santos (2008) distinguished three stages: production of scientific and technological knowledge, transforming knowledge into working artifacts, and responding to and creating market demands. For the purposes of our study, we identify four generic phases of innovation processes: detecting and making sense of the problem, creating ideas to solve the problem, studying and developing solutions to the problem, and adopting a solution. We find these phases independent of the type of the innovation and the innovation process.

Connectedness and Flexibility in an Innovation Process

Two characteristics of organizations are important for successful innovation processes: connectedness and flexibility. Both are necessary throughout the innovation process, although with varying emphases.

Connectedness is the ability of people to relate with each other inside and outside the organization (Jansen et al., 2006) in the interactive webs of relationships embedded within social networks (Cross & Parker, 2004). Human connections such as trust, personal networks, and sense of community play important roles in thriving organizations and contribute to knowledge sharing, innovation, and high productivity (Cohen & Prusak, 2001). Innovation communities often involve interpersonal ties that provide sociability, support, information, a sense of belonging, and social identity (von Hippel, 2005) Most of the work in organizations is not done through the formal organizational structure but rather through informal social networks, and the multiple dimensions of communication therein dictate an organization's ability to innovate (Cross & Parker, 2004).

Networks are communities of practice in which connectedness is built upon shared histories, experiences, reciprocity, affections, and mutual commitment, and which contribute to organizational learning and innovation through engagement, imagination, and alignment (Wenger, 2000). Any process of knowledge socialization and collective learning is based on relationships of meaning building and sharing within a context of coparticipation that promotes the development of shared values, reciprocity, and mutual trust (Sawhney & Prandelli, 2000). Knowledge building occurs by combining people's distinct individualities with a particular set of activities, and it is this combination that enables innovation (Leonard-Barton, 1995). Networks are not only a means of accessing distributed information and capabilities, but also a form of coordination guided by the enduring principles of an organization (Kogut, 2000). Practice creates epistemic differences among the communities within an organization, and the organization's advantage lies in dynamically coordinating the knowledge produced by these communities despite such differences (Brown & Duguid, 2001).

Connectedness is emphasized in the early phases of innovation processes, and is essential for gathering knowledge from innovation networks inside and outside the organization about market needs, other companies, and new possibilities (Siebra et al., 2008). Connectedness increases opportunities for informal interaction and accessibility to knowledge sources and also helps individuals to combine knowledge and to create new knowledge (Jansen et al., 2006). Dense social relationships resulting from connectedness help individuals share experiences. Connectedness forms the foundation for developing trust and cooperation among individuals, which subsequently develops a deep understanding for refining and reshaping existing products, processes, and markets (Jansen et al., 2006). Connectedness also relates to openness to new ideas, because innovation requires people to combine ideas, capabilities, skills, and resources in new ways (Fagerberg, 2003).

Flexibility is the ability of an organization to respond to potential internal and external changes in a manner that sustains or increases its value delivery (cf. Browne, Dubois, Rathmill, Sethi, & Stecke, 1984). Flexibility is not merely adapting to the changes in the environment but embracing change: It is a two-way process in which the organization not only reacts to change but also influences it (Conboy & Fitzgerald, 2004). Flexibility is particularly important in innovation processes that are internal to organizations in that internal innovation requires implementation in the organization. In such an innovation process, flexibility is emphasized in the later phases because the greater the innovation, the more it necessitates organizational changes and the more complicated it is to adopt (Chesbrough, 2003). The willingness of managers and other employees to change their ways of doing things, particularly in willingness to engage risk, is important for new ideas to be translated into action (Shavinina, 2003). ICTs play a role in organizational innovation as well, because they can further an organization's ability to adapt and be competitive (Fitzgerald & Wynn, 2004).

Agility is a term that combines flexibility and speed (Conboy & Fitzgerald, 2004). Seo and La Paz (2008, p. 136) defined organizational agility as a set of processes that allow an organization to sense changes in the internal and external environment, to respond efficiently and effectively in a timely and cost-effective manner, and to learn from the experience to improve the competencies of the organization. MacKinnon et al. (2008) discussed strategic flexibility, referring to an organization's deliberately crafted agility to recognize, assess, and act to mitigate threats and to exploit opportunities in a dynamically competitive environment. Strategic flexibility also refers to a set of organizational abilities to behave proactively and/or to respond quickly to a changing competitive environment, and thereby to develop and maintain a competitive advantage.

Zhang (2005) identified two organizational capabilities crucial to a firm's ability to pursue a variety of strategic options in responding to changing markets: product flexibility and cross-functional coordination. Product flexibility enables an organization to manipulate its product variety and to change efficiently and rapidly, thus developing more product strategy options to address environmental uncertainties. Tight cross-functional coordination within and across organizations promotes the smooth acquisition and sharing of critical information that the organization needs to quickly detect market and product changes, to redesign business processes and work flows, and to develop new insights and skills.

ICT in Innovation Processes

Information capital is an essential category of assets for implementing any business strategy, which includes the organization's databases, information systems, networks, and technology infrastructure (Kaplan & Norton, 2004). In contemporary organizations, ICTs pervade every aspect of an organization's value chain as a vast electronic network of interconnected applications and data (Kohli & Melville, 2009). The innovation processes and the organization's daily operations, which might change in the implementation of an innovation, rely on ICTs. The strategic readiness of information capital measures how well the IT infrastructure and applications support the critical internal processes (Kaplan & Norton, 2004). From the viewpoint of innovation processes, this includes a demand for ICT solutions and services that support and enable organizational connectedness and flexibility.

McAfee (2006) suggested that ICTs set off several kinds of revolutions in organizations and identified three distinct categories of these technologies (see Table 1). The first category, Function IT, involves technologies that make the execution of stand-alone tasks more efficient, technologies such as simulators, spreadsheets, computer-aided design, and statistical software.

Table 1. The Three Varieties of Work-changing Information Technology (IT; McAfee, 2006, p. 145).

Category	Definition	Characteristics	Examples
Function IT	IT that assists with the execution of discrete tasks	Can be adopted without complements Impact increases when complements are in place	Simulators, spreadsheets, computer-aided design, and statistical software
Network IT	IT that facilitates interactions without specifying their parameters	Does not impose complements but lets them emerge over time Does not specify tasks or sequences Accepts data in many formats Use is optional	E-mail, instant messaging, wikis, blogs, and mash-ups
Enterprise IT	IT that specifies business processes	Imposes complements throughout the organization Defines tasks and sequences Mandates data formats Use is mandatory	Software for enterprise resource planning, customer resource management, and supply chain management

They enhance experimentation capacity and increase precision. These technologies achieve their highest value when they have complements, such as new design processes. The second category, Network IT, provides the means by which people communicate with one another, such as e-mail, instant messaging, blogs, and groupware. They facilitate collaboration, allow expressions of judgment, and foster emergence. These technologies bring complements with them but allow users to implement and modify the complements over time. Finally, Enterprise IT encompasses applications that organizations adopt to restructure interactions among groups of employees or with external partners, such as software for enterprise resources planning, customer resource management, and supply chain management. They redesign business processes, standardize work flows, and monitor activities and events efficiently. These technologies introduce new interdependencies, processes, and decision rights, and necessitate organizational changes as soon as the new systems go live.

According to McAfee (2006), the adoption of the various types of technologies set different challenges for the organization’s management. For Function IT, the managers’ main responsibility is to help create the complements that will maximize the technologies’ value. Because Function IT does not bring its complements with it, managers must find ways to identify them and spur their use. For Network IT, because the use is voluntary, the managers’ role is more demonstrative, that is, showing how these technologies can be used and setting norms for participation. The most challenging type of technology to adopt in organizations is Enterprise IT. They define new cross-function business processes that impose the processes on employees without allowing employees to modify them and, thus, bring higher levels of oversight. In some cases, management may need to intervene forcefully throughout the adoption, when new processes, changed decision rights, and greater interdependence are introduced.

ICTs have dual importance from the viewpoint of innovation processes. First, innovation processes are enabled by appropriate ICT solutions and hindered by inappropriate ones. The first phases of innovation processes concern detecting and making sense of the problem and then creating ideas to solve the problem, and thus necessitate a great deal of investigation and collaboration. Technologies in the first two categories, Function IT and Network IT, are emphasized here because investigation and collaboration can be supported by, for example, knowledge management systems (Alavi & Leidner, 1999; Robey, Boudreau, & Rose, 2000) and networking and collaboration tools (Schneidermann, 2007). Additionally, various social media applications may enable social creativity and networking (Schneidermann, 2007). The need for collaboration continues in the later phases, in addition to support for developing and implementing the innovation. Various modeling and simulation tools, as well as prototyping systems, become helpful in studying and developing solutions to the problem (Schneidermann, 2007).

Secondly, adopting an innovation in an organization often involves changing the tasks or processes that the current ICT solutions support, and hence the adoption may be enabled or hindered by these solutions. Here, the flexibility and agility of an organization to take the innovation into use become important. In relation to innovations that are intended for improving the performance of an organization, this concerns the flexibility of the organization's ICT solutions and services and the agility of the organization to carry out ICT-related changes. Different solutions bring forth different issues to consider. For example, the flexibility of an enterprise resource planning (ERP) system refers to allowing changes in the ways of working. ERP systems integrate internal and external management information across an entire organization, and they often have caused trouble in process changes, such as delays in implementation, increasing staff requirements, and system upgrade problems (MacKinnon et al., 2008). As a result, the ability to adjust rapidly to changing business needs has become one of the essential requirements of ERP systems (Kirikova, 2009). Implementing a mix of information systems and integrating them through suitable middleware is a more flexible solution and less disruptive to the organization, but because the software packages typically come from different vendors, integration problems may arise, and maintenance and upgrades are more problematic than in ERP systems (MacKinnon et al., 2008). Regardless of the solution, a flexible ICT infrastructure should ease the transformation or at least not hinder the change.

The definition of an ICT (or IT) infrastructure varies in the literature. Duncan (1995) defined IT infrastructure as a set of tangible assets, including platform technology, network and telecommunication technologies, key data, and core data processing applications. Rockart, Earl, and Ross (1996) concurred with the four assets but required integrating and interconnecting them in a way that, from the viewpoint of users, all types of information can be expeditiously and effortlessly routed through the network. Typical functional requirements for a flexible ICT infrastructure are extensibility, adaptability, and integratability. Byrd and Turnder (2000) identified both technical and human components. Thus, technical IT infrastructure includes IT connectivity, application functionality, IT compatibility, and data transparency, whereas the human IT infrastructure includes technology management, business knowledge, management knowledge, and technical skills. The latter are components that combine business processes and ICTs in an effective way. A flexible ICT infrastructure should enable the organization to embrace changes and provide relevant data for decision making.

In aligning business processes and ICT infrastructure, the enterprise architecture plays an essential role (Pavlak, 2006). Enterprise architecture is a "blueprint" that specifies the main components of the organization, its information systems, the ways in which these components work together to achieve defined business objectives, and the way in which the information systems support the business processes of the organization (Kaisler, Armour & Valivullah, 2005). Enterprise architecture establishes an organization-wide road map to achieve the organization's mission through the optimal performance of its core business processes within an efficient ICT environment (Institute for Enterprise Architecture Developments, 2007). It is used for defining and controlling the interfaces and interaction of all of the components of the information systems and organizational units (Zachman, 1999). The enterprise architecture provides important added value for the organization and facilitates more effective strategy making and better knowledge of the effects of various decisions by high-level management (Varveris & Harrison, 2005). It is essential for evolving current information systems and developing new systems that optimize their mission value (Institute for Enterprise Architecture Developments, 2007). In order to support an innovative organization, the enterprise architecture must include characteristics that support connectedness and flexibility.

Various frameworks have been developed to provide a common basis for describing enterprise architectures, for example, the Zachman Framework (Zachman, 2008) and TOGAF (The Open Group, 2010). The framework used in this study is the enterprise architecture grid (EA Grid; Hirvonen & Pulkkinen, 2004; Pulkkinen, 2006; Pulkkinen & Hirvonen, 2005), which is based on TOGAF. We describe the framework below.

RESEARCH SETTING AND METHODOLOGY

In this section, we present the empirical foundation for our study. We define the objective and questions of our study, introduce the research framework, and describe the research methodology and process.

Research Objective and Questions

This study was carried out within a multidisciplinary research project on the added value of intangibles for organizational innovation. Adopting the resource-based view (Penrose, 1959), we propose that sustainable competitive advantage results from intangible assets because they enable the accumulation of other types of assets. The project focused on intangibles as drivers of organizational innovation in Finnish companies that are active in an international context. The overall objective of the project was to identify critical factors for the intangibles that support innovation in organizations. The purpose is to reduce unnecessary barriers in the organizations' systems and procedures, and strongly stimulate connectedness and flexibility that are important for innovation. The results will be used to construct a tool that supports analysis and gives directions for improving innovation performance. In addition, ways for improvement and change management will be indicated. The project focused on intangibles in the areas of human resources, communication, marketing, and ICTs.

In this study, we focused specifically on ICTs. The objective of the study was to identify intangible ICT-related factors that enable connectedness and flexibility in organizations, as well as related metrics for assessment and improvement. The research questions were the following:

1) Which intangible ICT-related factors are important for innovation processes in light of enabling connectedness and flexibility in organizations?
2) What metrics are needed for their assessment and improvement?

To answer these questions, we first searched for issues that hinder connectedness and/or flexibility and tried to understand what makes them hindrances. The factors were then reframed as the polar opposites of these issues and restated as indicators. Metrics were then formulated, based on what is needed to remove hindrances.

We recognize that the relationship between ICT-related factors and their effects on organizations is complex, mediated, and uncertain. The relationship can be described as having functional affordances, that is, possibilities for goal-oriented action afforded to specified user groups by technical objects (Markus & Silver, 2008). Whether the fulfillment of certain ICT-related indicators actually leads to organizational innovativeness depends on other organizational factors and people, but their absence is likely to slow down or hinder innovation processes.

Research Framework

We took a resource-based view on ICT-related intangible assets. According to this view, anything that could be thought of as a strength of a given organization can be viewed as a resource, for instance, brand names, in-house knowledge of technology, employment of skilled personnel, trade contacts, machinery, efficient procedures, and capital (Wernerfelt, 1984). Intangible assets are resources that have no physical existence—they are inimitable, rare and nontradeable (Lev, 2001). The resource-based view suggests that intangible assets are elemental for creating and sustaining a competitive advantage because they enable the accumulation of other types of assets (Penrose, 1959).

Distinguishing between tangible and intangible assets is not always an easy task where ICTs are concerned. Without doubt, the physical technology, hardware, and networks, including any of their physical characteristics, are tangible. However, software and data cannot, self-evidently, be classified as tangibles. A running software application requires a physical medium for its existence and to enable people to interact with it, but the physical characteristics are not the only thing people deal with when they use the software. The support that the program provides to the users is very much intangible. The difference involved here is similar to the difference between a book (tangible) and its contents (intangible). Therefore, the availability of a technical means may also contribute to intangible capabilities. Furthermore, software systems require organization-specific processes, such as configuration, integration, and maintenance, to operate. Although some of the prerequisites and results of these processes are tangible, the procedures are not.

In this study, we used an enterprise architecture framework to aid in the identification of intangible ICT-related factors. This was a natural choice for two reasons: (a) assessments, decisions, descriptions, and catalogs of ICT-related assets are a large part of enterprise architecture; and (b) connectedness and flexibility require decisions to be made regarding the enterprise architecture in order to achieve them in practice.

We selected the EA Grid (Hirvonen & Pulkkinen, 2004; Pulkkinen, 2006; Pulkkinen & Hirvonen, 2005) as the specific framework. It has been used for developing and improving enterprise architectures in many organizations, for example, the Ministry of Finance in Finland. The EA Grid describes enterprise architectures from four different viewpoints (cf. Hirvonen & Pulkkinen, 2004):

> *Business architecture* describes the components of the enterprise and their interrelationships, such as business objectives and principles, business processes,

service structures, and organizational activities. These provide guidelines for the structure and functions of the enterprise. In this study, we were interested in the components that relate to the organization of ICT services in an enterprise. We also note important business-related prerequisites to successful organization of ICT services.

Information Architecture focuses on information services required by business processes, services, and activities, including information structures and their interconnections, and principles governing their development, maintenance, and use. Examples of such structures are metamodels, vocabularies, and data models. These provide guidelines for information services used by business processes and services. In this study, we were interested in the types of structures that relate to using ICT in the creation, maintenance, and use of information.

Systems Architecture represents the information systems that provide support for business processes and information services, their interconnections and characteristics, and the principles governing their development, maintenance, and use. These provide guidelines for the support of business processes and services. This part of the enterprise architecture is ICT-specific, and therefore we were interested in any related intangibles in this study.

Technology Architecture covers technological solutions, the various aspects of technology infrastructure, structural components, and interrelationships, as well as the related principles for building information and communication systems, such as application technology, hardware, and networks. These provide guidelines for the technological basis of information and communication systems. In addition, this part of the enterprise architecture is ICT-specific, and therefore we were interested in any related intangibles in this study. Because technology architecture covers mostly tangibles, it is likely that many surfacing issues should be noted as technological prerequisites.

The framework is illustrated in Table 2. The main purpose of the framework in our study was to aid the participants in thinking about issues from different viewpoints. Accordingly, we used the framework to organize the questionnaires and to categorize the identified factors. Each of the viewpoints included issues at strategic, domain, and system levels, but explicitly distinguishing between these levels would have unnecessarily complicated the questionnaire and hence reduced its usability in the study.

Table 2. Enterprise Architecture Grid as the Research Framework in this Study.

	Business Architecture	**Information Architecture**	**Systems Architecture**	**Technology Architecture**
Describes	Components of the enterprise and their interrelationships	Information structures and their interconnections	Information systems and their interconnections and characteristics	Technological structures and interdependencies
Role in the architecture	Guidelines for the structure and functions of the enterprise	Guidelines for information services used by business processes and services	Guidelines for the support of business processes and services	Guidelines for the technological basis of systems

Research Methodology and Research Process

We used the Delphi method in this study to identify various ICT-related factors that enable organizational innovation. The Delphi method (Linstone & Turoff, 1975) was developed originally for identifying future research, but it can be used as well for solving problems that cannot be solved by one exact analyzing technique. Information used in the solving process can be gathered from different persons or it can be based on an individual view. It can be used for gathering values, new points of view, or ideas to support planning and decision making.

In a Delphi study, a group of experts are used as the source to gather data for a specific well-defined and bounded research question. Due to the nature of the relationship between ICTs and their organizational effects, we decided to formulate the questions through a negation. Therefore, we asked for factors the experts believe may hinder an organization's flexibility and connectedness, thereby affecting negatively its innovation processes. For data gathering, we identified a group of ICT and innovation experts in Finland. The experts were chosen from universities, research institutes, businesses, and some public sector organizations. The invitation letter was sent via e-mail to 150 potential participants. 29 panelists responded anonymously to the questionnaire.

In a Delphi study, the data is gathered through two or three rounds of questionnaires that are tested and revised before being sent to the panelists. In this study, we collected qualitative data in two rounds. The first questionnaire was used to collect answers from the panelists individually. We asked them to identify factors that may hinder an organization's flexibility and connectedness in each of the categories of the research framework; there was no limit to how many factors each participant could suggest, nor a condition that all categories had to be addressed. In the analysis of the answers, we first collected similar comments into each category and formulated statements thereof. Whenever we detected different opinions or viewpoints, we formulated the statements in a way that showed these differences. The formulations were made by one researcher and double-checked by another to ensure that they reflected the answers as accurately as possible. We then combined related statements and formed specific factors thereof. This was done by two researchers reviewing and revising each other's formulations.

In the second round, the compiled lists of factors and related statements were given to the panelists for comments, corrections, and additions. In cases of differing opinions or viewpoints, the panelists were asked to discuss their perspectives and try to reconcile on the issue. The responses were collected anonymously via a wiki so that all the panelists could see and comment on each other's comments. The data gathered in the second round was used to revise and enhance the factors identified in the first round.

When the second round was completed, we formulated a list of indicators and statements based on the gathered data. If the panelists had not reconciled on a factor or a statement, that factor or statement was omitted. Finally, the data and relevant literature were used for identifying related metrics.

RESULTS

In this section we present the results of our Delphi study. About half of the factors identified in the study were found suitable for creating intangible ICT-related indicators, while the others serve as prerequisite factors for the indicators. In the following subsections, the prerequisite factors are mentioned only briefly because the main focus is on the indicators as the objective of this study. We present the results in each category of the research framework.

Business Architecture

Business architecture describes the basic components of the enterprise, such as business processes, service structures, and organizational activities. Those components may exist even without any digital information processing devices. From the viewpoint of ICT infrastructure planning, business architecture is the foundation upon which the actual planning will be based (Hirvonen & Pulkkinen, 2004). In order to achieve a flexible ICT infrastructure, business architecture should be designed flexibly before planning how to support the processes with ICTs. On the other hand, a flexible ICT infrastructure makes the ability to change in business architecture possible in the first place.

We identified a set of prerequisite factors related to organization and business processes that should be mentioned as a background for the indicators. These factors remind us that ICTs cannot remedy the shortcomings in the organization, its ways of working, or its culture. To set the foundation for a flexible business architecture, unnecessary size, complexity, and hierarchy should first be removed from the structures and organizational integration by way of well-working cross-functional operational and management processes. Agile, open, and networked interaction should be fostered in the activities both horizontally and vertically. Sufficient resources should be allocated for the creation and maintenance of an innovative operational environment. Then, business processes should be integrated so as to cover the entire value chain from suppliers to customers, and to meet the organization's business needs, strategies, and goals. These processes should be meaningful, fluent, and practical in providing services for customers. Processes should be locally flexible, enabling the details of work and workflows to be decided and negotiated where the actual work is done. When the organization and its business processes are designed to embrace opportunities for innovativeness, suitable ICT services can be implemented to support them. In the following paragraphs, we describe the identified indicators and metrics that relate to business architecture (see also Table 3).

Indicator 1: Top management should be competent in ICT-related issues. Ignorance of or distrust towards ICTs may be present in the top management, which may hinder decision making on ICT-related issues and comparisons of the effects, advantages, and disadvantages of different choices. Top management should have an open but realistic attitude towards ICTs and how they contribute to business innovation, and then base decisions on well-grounded expert evaluations. ICTs are strategically important because they should, as services and tools, help achieve the organization's strategies. Therefore it is important that the director of the IM (information management) function participates in the organization's highest level decision making and brings forth technological issues and options in the discussion.

Indicator 2: ICT services should meet the needs of business processes and their integration. In contemporary organizations, the implementation of business processes relies largely on the provided ICT services. Unless the ICT services support business processes and the business processes are adapted to new ICT solutions, real benefits are not gained. This concerns innovativeness as much as any other characteristic. The provided ICT services should cover all

Table 3. Key Indicators Identified for Business Architecture.

Indicator	Statement	Measurement
Indicator 1 ICT Competence of Top Management	Top management is competent in ICT-related issues.	Top management has an open but realistic attitude towards ICT and bases its decisions on well-grounded expert evaluations. The director of the IM function participates in the organization’s highest level decision making.
Indicator 2 Matching ICT Services and Business Processes	ICT services meet the needs of business processes and their integration.	The provided ICT services cover all aspects of business processes. All gaps between ICT services and business processes have been identified and dealt with efficiently.
Indicator 3 Information Management Functions as a Service Provider	The IM function operates as a service provider for users.	The operations of the IM function are organized and managed as services. IM personnel perceive themselves as service providers. ICT services are designed as services for users, and users interact directly with the designers of the services to improve them. User training is well-planned and organized.

aspects of business processes, and any gaps between the processes and ICT services need to be identified and dealt with efficiently.

Indicator 3: The IM function should operate as a service provider for users. The IM function’s role in the organization may be perceived too often as a technology provider instead of focusing on providing services. The basis of a service orientation is that the operations are organized and managed as services and that the IM personnel perceive themselves as service providers. If ICT services are not designed from the viewpoint of the users, then service roles may become blurred. Furthermore, although ICT services may become more fluent for the IM function, service tasks typically are not reduced but just transferred to the users. When this happens, the overall efficiency does not improve and the result may be even more costly. ICT services should be designed as services for the users, and the users should interact directly with the designers of the services to improve them. ICT services should also be accompanied by well-planned and organized user training.

Information Architecture

Information architecture focuses on the information used, created, and stored in a business, including high-level structures of business information and, at a more detailed level, the data architecture (Hirvonen & Pulkkinen, 2004). In the following we describe the identified indicators and metrics that relate to information architecture (see also Table 4).

Table 4. Key Indicators Identified for Information Architecture.

Indicator	Statement	Measurement
Indicator 4 Clarity in the Provision of Information Services	Information services have been defined.	Information requirements of different business processes have been identified. Information flows have been optimized to ensure that correct information is delivered timely to the right place when needed.
Indicator 5 Cross-organizational Interoperability	Cross-organizational interoperability is enabled.	The needs for cross-organizational interoperability have been identified. Standardized data formats or application interfaces are used for cross-organizational data transfer.
Indicator 6 Support for Perceived Added Value of Information Capital	The users have support for perceiving and utilizing the added value of the information residing in the organization's data repositories and other information sources.	Means exist to analyze, parse, and filter data from different information sources. Ability to share and store tacit and informal knowledge is established.
Indicator 7 Integrated Data Models	The organization's data models are integrated.	Data models are compatible with the operational ontology of the organization's information services. Master data have been identified and managed with appropriate tools. Metadata are specified extensively and consistently based on a common vocabulary and schemes.
Indicator 8 Ability to Transfer Data Between Information Systems	Data repositories enable flexible and reliable data transfer between systems.	Data models are compatible with the operational ontology of the organization's information services. Master data have been identified and managed with appropriate tools. Metadata are specified extensively and consistently based on a common vocabulary and schemes.

Indicator 4: Information services should be defined. Information requirements for business processes should be identified and information flows optimized so that correct information will be delivered in a timely fashion to the right place when needed. Access to information should be flexible and unobstructed. According to Alavi and Leidner (1999), the free information flow between and among applications and people makes an organization able to react flexibly to changes needed for innovations.

Indicator 5: Cross-organizational interoperability should be enabled. Converting data from various entities or from different contexts for the organization's data repositories may be time consuming and reduce the organization's ability to take action in a timely manner (Seo & La Paz, 2008). Standardization of data formats or application interfaces is a good solution for cross-organizational interoperability, particularly when the interaction is frequent and continuous, such as between partnering organizations. The needs for cross-organizational interoperability should be identified so that standardization can take place and the necessary application interfaces implemented.

Indicator 6: The users should have support for perceiving and utilizing the added value of the information residing in the organization’s data repositories and other information sources. Added value will be lost if the potential of existing information capital is not perceived and utilized for creating new competences and knowledge, enhancing existing processes, or creating additional services or new products. Perceiving is difficult when huge amounts of unstructured information exist and its context and relevance are not clear (Seo & La Paz, 2008). The users should have support for perceiving and employing information from various sources to create added value. Knowledge management systems are necessary to provide this support in a complex information environment, but they require that information is stored in a way that is easy to locate, access, and analyze (Alavi & Leidner, 1999). Data gathered from various sources should be parsed into a standardized format that can be used efficiently by the organization’s information systems. Information filtering may be needed so that only reusable and relevant data are stored (Seo & La Paz, 2008). An important source of information is people, and therefore means by which to share and store tacit and informal knowledge is essential.

Indicator 7: The organization’s data models should be integrated. Without integration, the organization’s data become fragmented, which means that the same data are stored in different systems, possibly using different formats, different concepts, and even having different contents. Fragmentation leads to the vulnerability of systems, duplicated storage, and poor access to data. Data models should be compatible with the operational ontology of the information services. In a fragmented data environment, master data should be identified and managed with appropriate tools. Metadata should be specified extensively and consistently based on a common vocabulary and schemes.

Indicator 8: Data repositories should enable data transfer between different systems. Flexible and reliable data transfer between different information systems is not possible if the organization’s data repositories do not have interfaces for integration or the interfaces are not adequate for the purpose. In addition, if data repositories require ad hoc fixes to meet the data transfer needs, changes to systems become increasingly difficult to manage and integration is vulnerable. Data repositories should have interfaces that enable all necessary data transfer between different systems.

Systems Architecture

Systems architecture represents the information systems and their interconnections. Major components thereof are organizational information systems, which are usually implemented either as one-vendor ERP systems or as a combination of different software packages (MacKinnon et al., 2008). In the following we describe the identified indicators and metrics that relate to systems architecture (see also Table 5).

Indictor 9: The organization’s systems architecture should be well-planned, unified, and consistent, and used as a basis for system acquisition and utilization. An organization may use a number of different information systems that need integration, and such complexity is

Table 5. Key Indicators Identified for Systems Architecture.

Indicator	Statement	Measurement
Indicator 9 Systems Architecture	The organization's systems architecture is well-planned, unified and consistent, and it is used as a basis for system acquisition and utilization.	The roles and interdependencies of different systems and applications in the organization's business processes have been specified. Common system standards and directions for lean and flexible acquisition processes have been specified.
Indicator 10 Systems Integration	The organization's information systems can be integrated rapidly and reliably.	Information systems provide adequate and documented interfaces for their integration. Information systems are integrated with suitable middleware, or an organization-wide ERP system has been implemented.
Indicator 11 Upgrades and Realignment of Systems	Existing information systems are upgraded and realigned easily and rationally.	Systems can be upgraded and realigned without changes in other systems and unwanted side effects. Upgrades and changes are made only if they are business-wise necessary.
Indicator 12 Support for Business Processes and Innovation Activities	Information systems provide the support needed in business processes and innovation activities.	Information systems and applications support all aspects of business processes and innovation activities. New applications suitable for innovation activities are identified continuously and their use is promoted. Information systems enable gathering and reporting of information on the organization's business performance.
Indicator 13 Usability and Flexibility of Systems and Applications	The use of systems and applications is easy and flexible.	Systems and applications support meaningful ways of working. Systems and applications are easy to use together, transparent and clear to use, and their user interfaces are well-designed for the task. Systems and applications can be customized to special user needs, and varying mental and operational models.

very difficult to manage successfully. A well-planned, unified, and consistent systems architecture is required to enable rational and well-grounded decision making and systems acquisition and integration so that the output is optimal for the organization. The systems architecture should specify the roles and interdependencies of various systems and applications in the organization's business processes. It should set common system standards and give directions for lean and flexible acquisition processes.

Indicator 10: Information systems should be rapidly and reliably integrable. A major issue in enabling organization-wide and fluent business processes is system integration. Integration is difficult or even impossible if the organization's information systems are incompatible, do not have adequate interfaces or the number of interfaces is too great to manage, or the interfaces have not been documented. Information systems should provide adequate and documented interfaces for their fluent and reliable integration. Point-to-point integration, the so-called spaghetti integration, is a maintenance nightmare when many systems need to be integrated. Individual systems should provide adequate interfaces for their integration, and they should be integrated with suitable middleware (MacKinnon et al., 2008; Zhang, 2005). Another choice is to implement an organization-wide ERP (MacKinnon et al., 2008).

Indicator 11: Existing information systems should be easily and rationally upgraded and realigned. Whether an organization decides to use middleware for system integration or to implement an organization-wide ERP system, the solution should support modularity. This means that the individual systems or system modules can be changed and new ones added without changes in other systems or modules (Chung, Byrd, Lewis, & Ford, 2005). The larger the change, the more time it takes, the more side effects are to be expected, and the higher the cost. Another problem involves ongoing changes to and in software. Frequent upgrades and software changes make the management of systems difficult, and new systems and versions may not be adequately perfected. Supplier-driven upgrades and changes are not necessarily wise for the organization. Therefore upgrades and changes should be made only if they are beneficial for the business (Kankaanpää & Maaranen, 2009).

Indicator 12: Information systems should provide the support needed for business processes and innovation activities. It should be ensured that information systems and applications support all aspects of business processes and innovation activities. Externally available applications and systems also should be considered. New applications suitable for innovation activities should be identified continuously and their use promoted (e.g., social web applications). Information systems should enable gathering and reporting of information on the organization's business performance, so that needed improvements can be detected in a timely manner.

Indicator 13: The use of systems and applications should be easy and flexible. Systems and applications often are difficult to use, take more time than is reasonable, and divert attention from the actual task. The benefits of use may be unclear, which weaken the users' motivation to use them. Systems and applications should support meaningful ways of working. They should be easy to use together, transparent and clear to use, and the interfaces should be well-designed for the task. Systems and applications also should be customizable to users' special needs, as well as to the varying mental and operational models of the users.

Technology Architecture

According to Pulkkinen (2006), technology architecture concerns the technologies and technological structures used to build information and communication systems, such as application technology, hardware, and networks. The key task of technology architecture is to offer technological possibilities for flexible information systems and other innovation supporting tools.

We identified some technological factors that, as tangibles, cannot be included as indicators, but which are important prerequisites for intangible assets. First, the speed, flexibility, capacity, and coverage of the internal and external technology infrastructure should meet the needs of the organization's information services and systems. Second, many of the previously discussed integration and management issues require the various tangible technologies and technology platforms to be integrated and managed properly, and that technology-independent external access to the organization's data and systems is possible. Third, the various tangible technologies should be easy to use and easily adapted to different user needs. We now describe the identified indicators and metrics that relate to technology architecture (see also Table 6).

Indicator 14: Technology-related decisions, and the acquisition, implementation, and maintenance of technology are well-planned and organized. Common technology architecture, standards, and a strategy should be defined: The lack thereof easily leads to a fragmented and unmanageable technology infrastructure. These should be consistently used in decision making, acquisition, and maintenance.

Indicator 15: Adopted technology is affordable and easy to maintain. The existing technological solutions should be documented in a way that their life cycles can be managed. It should be possible to implement new technological solutions smoothly and without heavy additional investments. Maintenance of technology should not be dependent on any one person or supplier because the loss of that person or supplier would pose a great risk for the organization.

Table 6. Key Indicators Identified for Technology Architecture.

Indicator	Statement	Measurement
Indicator 14 Management of Technology	Management of technology is well-planned and organized.	A common technology architecture, standards, and strategy have been defined, and they are consistently used in decision making, acquisition, implementation, and maintenance.
Indicator 15 Acquisition and Maintenance of Technology	Adopted technology is affordable and easy to maintain.	The existing technological solutions have been documented in a way that their life cycles can be managed. New technological solutions can be implemented smoothly and without heavy additional investments. Maintenance of technology is not dependent on one person or supplier.

DISCUSSION AND CONCLUSION

In this study, we employed an internal organizational approach to the innovation process. The importance of connectedness and flexibility in the various phases of the innovation processes has been noted in previous research. Both are needed throughout the process, but we conclude that they are emphasized differently. Connectedness is emphasized in the early phases of the innovation process because it is required for gathering knowledge from innovation networks inside and outside the organization. Flexibility is emphasized in the later phases because of the needed organizational changes. If the aim of innovation is to improve the performance of the organization, the flexibility of the organization’s ICT solutions and services and the agility of the organization to carry out ICT-related changes are extremely important.

Our findings confirm that organizational issues related to ICTs are very important; indeed the majority of the identified factors are found in the business architecture category, and only about a half of these factors deal with ICTs or information management. Innovativeness should be a strategic concern for the organization. Lean and well-functioning business processes and organizational structure are necessary foundations for good ICT-related decisions. The strategic role of ICTs in achieving business processes and innovativeness should be recognized as well. When the organization and its business processes are designed to embrace opportunities for innovativeness, suitable ICT services and systems can be implemented to support them. ICT solutions have limitations, however, which need to be considered during planning and implementation.

Clearly a major issue identified in this research for enabling connectedness and flexibility is integration. Factors related to integration can be found in all categories, extending from organizational and business process integration to systems and technological integration. Integration is a concern not only within the organization but extends beyond the organizational boundaries. Integration creates a basis for well-functioning connections within and between organizations, and is necessary for connectedness. Flexible integration, on the other hand, is a basis for flexible organizational structures and ways of working, which are needed for implementing the changes involved in adopting innovations. In this way, integration is important both in the early phases of innovation processes by enabling connectedness and in the later phases by enabling flexibility.

Service thinking and user-orientation also arose in several indicators. They show a requirement for fitness, fluency, and flexibility that not only relates to existing processes and workflows but also promotes innovation therein. Fluent workflows and ways of working with well-designed and adaptable tools enable users to focus on their actual work instead of the systems and applications they are using. Service orientation also helps the service provider understand the customer’s business processes or the users’ ways of working, thereby improving the ability to detect and embrace opportunities for new service innovations.

A single but rather obvious factor is the need for systems and applications that support business processes and innovation activities. The systems and applications should support, for example, cooperation, information gathering, and learning. Different aspects mentioned in the responses include group work, networking, unified communication, customer relationship management, data mining, and tacit knowledge sharing. Largely, these support the early phases of innovation processes not only by enhancing connectedness among people but also by improving the accessibility, retrieval, and processing of information. The organization should be active in searching for new systems and applications, identifying the opportunities they may give, and promoting the use of new tools in its innovation processes.

We conclude that it is necessary for organizations to consider ICT-related factors when they intend to improve their innovation activities. ICTs can enhance connectedness and flexibility throughout the innovation process, but they do not lead to organizational innovativeness independent of other organizational factors and people. If the organization is well-functioning, suitable ICT solutions can provide important value adds for its innovation activities.

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