A Model of Coaligned Digital Innovations: The Roles of Flexible IT Infrastructure and Ambidextrous IS Process Innovations

Research-in-Progress

Jeffrey C. F. Tai **Eric T. G. Wang**

Kai Wang

Abstract

Digital technology is a species of information and communication technology characterized by reprogrammability, the homogenization of data, and self-referentiality. Such properties provide convergence and generativity affordances for creating multiple types of digital innovations. This study proposes a new construct "coaligned digital innovations" to capture the idea of simultaneous innovations on product, process, and business model, embodied in or enabled by digital technologies. Based on the service-dominant logic, this study posits that flexible IT infrastructure (as operand resources) can directly facilitate coaligned digital innovations or indirectly accomplish so through ambidextrous IS process innovations (operant resources). As a result, a model with three sets of research hypotheses is formulated. The potential implications are also discussed.

Keywords: Coaligned digital innovations, ambidextrous IS process innovations, IT infrastructure flexibility, service-dominant logic

Introduction

Digital technologies are a new species of information and communication technologies (ICT) with the affordances of reprogrammability, homogenization of data, and self-referentiality (Yoo et al., 2012). Digital technologies make physical products, services, and processes programmable, addressable, sensible, communicable, memorable, traceable, and associable by embedding them with software-based digital capabilities. The changes embodied in or enabled by such technologies are referred to as *digital innovations*, ranging from products, processes to business models (Fichman et al., 2014).

The diffusion of ICT-based innovation has been the research focus of early IS scholars. Past studies predominantly applied the economic-rationalistic viewpoint, which attempted to identify the "right stuffs" (e.g., firm size and structure, knowledge and resources, management support, compatibility, and competitive environment) for improving the quantity and quality (e.g., frequency, earliness, or volume) of an organization's innovation adoption. Since 2010s, digital innovations began to receive an increasing research attention. Such research highlighted the idea of *generativity*, stressing the overall capacity of digital technologies to produce unprompted changes driven by large, varied, and uncoordinated audiences. Specifically, the layered modular architecture and loose-coupling of digital

components were considered to be the pivotal mechanisms engendering such affordances (Yoo et al., 2012). Accordingly, the organizing of technological components and innovation activities for exploiting the generativity of digital innovations emerges as a critical issue to be investigated by researchers.

Digital innovations typically produce changes that are not only different in degree but also different in kinds. For example, Fichman et al. (2014) distinguished digital innovations into product, process, and business model innovations. Although these forms of digital innovations are distinct, they entwine in important ways (Carlo et al., 2011). For instance, Netflix is a renowned digital product innovator for its development of analytics tools to produce customized video title recommendations. Since the use of analytics tools is embodied in the promotion practices (via customized video title recommendation on Netflix's website), Netflix engages in also digital process innovation. Netflix further carries out business model innovation because it shifts to improve customer satisfaction by offering customers personalized recommendation service and hence can rely less upon purchasing popular, expensive video titles. As such, Netflix shows that changes in digital technology-embodied product, process, and business model innovations are often intertwined with each other. Such interdependencies among various forms of digital innovations also can be found in industries such as digital music and wireless technologies (Boland et al., 2007).

When studying disruptive IT innovations (e.g., Internet computing), Lyytinen & Rose (2003) found that base technology innovations and other forms of innovations transformed by it often move in packs. Organizations thus no longer are faced with challenges of adopting and diffusing a single IT innovation; instead, they need to both create and assimilate various innovations in order to accomplish the whole set of disruptive IT innovations (Carlo et al., 2011). Because of generativity, recent research argued that digital technologies can instigate a new and yet complex pattern of IS development and organizing activities as well as business product and process changes (Boland et al., 2007). Therefore, this study similarly submits that firms seeking to exploit the fullest potential of digital technologies need to pursue *coaligned digital innovations*, defined as *simultaneous pursuit of digital technology-embodied changes in the aspects of product, process, and business model*. As a result, this study aims to shed light to the literature by investigating the following question: *How do firms leverage IT infrastructure to accomplish coaligned digital innovations?*

Conceptualization Foundation

Coaligned Digital Innovations

Innovation refers to the first or early use of an idea, material artifact, or behavior. Because applying such criteria to identify an innovation is difficult, innovation has been defined in terms of the newness or novelty from the adopter's viewpoint. IS innovation has been the construct mostly applied to describe novel organizational applications of information and communication technologies. Since functionally differentiated tasks are the targets of organizational innovations, Swanson (1994) proposed a tri-core typology to describe IS process innovations (i.e., the functional IS core) and their impact on business processes (i.e., the business administrative & technical core), as shown in Table 1.

Table 1. Comparison between IS Innovation and Digital Innovations

<table>
<tr><th colspan="2">Tri-core IS innovation</th><th>Digital innovations</th></tr>
<tr><td rowspan="2">Functional IS core</td><td>● Type Ia: IS administrative process innovation</td><td rowspan="2"></td></tr>
<tr><td>● Type Ib: IS technological process innovation</td></tr>
<tr><td>Business administrative core</td><td>● Type II: IS product and business administrative process innovation</td><td rowspan="2">● Digital process innovation: new ways of doing things in an organizational setting that are embodied in or enabled by IT</td></tr>
<tr><td>Business technical core</td><td>● Type IIIa: IS product and business technological process innovation</td></tr>
</table>

	• Type IIIb: IS product and business product innovation	• Digital product innovation: new products or services that are embodied in or enabled by IT
	• Type IIIc: IS product and business integration innovation	• Digital business model innovation: new ways of creating and capturing business value that is embodied in or enabled by IT

The functional IS core includes *IS administrative process* (Type Ia) and *IS technological process* (Type Ib) *innovations*. The former depicts new IS administrative arrangements, while the latter denotes new IS work technologies. The business administrative core is called *IS product and business administrative process innovation* (Type II), capturing business administrative innovation via IS products or services. The business technical core represents technological process, product, and integration innovations in business via IS products or services, including three sub-types: *IS product and business technological process innovation* (Type IIIa), *IS product and business product innovation* (Type IIIb), and *IS product and business integration innovation* (Type IIIc). As such, the functional IS core permeates and links both the administrative and the technical cores of organizations through influencing the development and management of IS products or services.

While the tri-core typology addresses the types of innovative IS activities and their business impact, the concept of digital innovation focuses on business innovations embodied in or enabled by IT (Fichman et al., 2014). Specifically, digital innovations can be categorized into *product*, *process*, and *business model innovations*, which correspond to Type IIIb, Type II & Type IIIa, and Type IIIc IS innovations, respectively (as shown in Table 1). Accordingly, this research will adopt Type II and Type III IS innovations to operationalize the concept of digital innovations.

Recent research also found that various forms of digital innovations can be interdependent, because one kind of digital innovation can enable or become a component of other kinds of digital innovations (Fichman et al., 2014). For example, Pixar has constantly innovated on technological process of film production (i.e., digital process innovation) in order to make the digitally animated films more vividly (i.e., digital product innovation). The firm's adoption of open source software to produce animated films also triggers new business models that can co-create value with business partners (i.e., digital business model innovation)(Nambisan, 2013). Since the business potential of digital technology-embodied innovations can be more fully realized by pursuing multiple forms of digital innovations that are intertwined with each other, we propose *coaligned digital innovation* to capture the phenomenon and defines the construct in terms of *the simultaneous adoption of digital product, digital process, and digital business model innovations*.

The Convergence and Generativity Affordances of Digital Technology

Digital technology refers to ICTs possessing three key properties (Yoo et al., 2012). First, digitalization permits *the homogenization of data*. As such, digitalized data can be stored and transmitted irrespective of its content type by any devices with computing capabilities. Second, digital technologies are *reprogrammable*. Hence, the functions of digital artifacts are malleable and can be changed dynamically. Third, digital technologies and artifacts can be *self-referential*. Thus, digital innovations are both the basis for and the outcome of changes embodied in or enabled by digital technologies.

The three properties render the convergence and generativity affordances to digital technologies and the embodied innovations (Yoo et al., 2012). As to the convergence affordance, digital innovations can be enabled by putting together either previously separated user experiences or digital capabilities with physical products on the basis of digital technologies (Tilson et al., 2010). For example, the so-called quadruple-play brings the experiences of telephony, broadband, mobile Internet, and TV together as a holistic service offering. Such digital innovation not only eliminates inefficiencies but also improve service quality that any individual service offering cannot provide.

Generativity refers to unanticipated outcomes produced by interactions with digital technologies (Yoo et al., 2012), which is embodied in several ways. First, reprogrammability permits the procrastinated binding of form and function in digital innovations. New capabilities thus can be added into extant

digital products/services flexibly. Second, the use of digital technologies leaves unprecedented volumes of digital traces as by products, thereby, allowing for creating a variety of derivative innovations. Third, digital technology-instigated changes can engender what Boland et al. (2007) called "wakes of innovation." This is because digital innovations involve a complex ensemble of technologies, work practices, and knowledge across heterogenous actors. An initial digital innovation hence can shape and subsequently be reshaped by reverberating innovations in which new knowledge, technologies, and practices are uniquely pursued by different actors. This in turn results in innovations that go beyond the initial intention of the original innovators.

New Ways of IS Development and Organizing for Pursuing Digital Innovations

Digital innovations are novel product, process, or business model changes embodied in or enabled by digital technologies. Such changes are realized by and delivered through IS products/services (Swanson, 1994). Therefore, in addition to digital technologies, IS development and organizing also matter to the pursuit of digital innovations.

Digital technologies fundamentally change the ways IS are developed and organized. On the one hand, the properties of reprogrammability and homogenization of data permit the separation of function and form as well as the separation of content and medium in digital innovations (Yoo et al., 2012). The former permits a digital artifact to be reprogrammed so that the same underlying form can deliver new functionalities; the latter allows digitized data from heterogenous sources to converge on any single medium. Although both properties render generativity, the risk of complex system failures also increases when digital innovations are pursued in combinatorial manner. Therefore, firms need to devise new ways of organizing IS development in order to balance the dual needs of generativity and delicate control (Ghazawneh & Henfridsson, 2013).

On the other hand, digital technology platforms emerge as a foundation upon which other firms can develop complementary products, technologies or services (Tiwana & Konsynski, 2010). Firms thus can develop IS products/services for digital innovations using common digital tools/components provided by these platforms. Moreover, such way of pursuing combinatorial innovations shifts the locus of innovation activities to the peripheral of organizations. The use of online communities and innovation contests to acquire innovative ideas further complicates the task of integrating heterogenous resources for generating digital innovations. Since the ownership and rules for governing sharable data, processes, and knowledge on various digital platforms differ from firm-specific organizing practices, firms need to conduct IS administrative innovations in order to improve the efficiency and effectiveness of IS activities (Yoo et al., 2012).

Research Model and Hypotheses

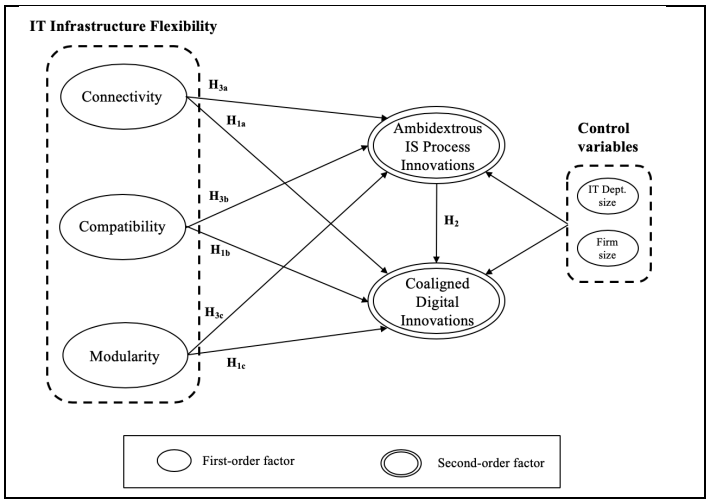

Figure 1. Research Model

This study investigates how and why digital product, digital process, and digital business model innovations can be accomplished simultaneously. Drawing on the properties of reprogrammability, homogenization of data, and self-referentiality, we posit that leveraging and managing convergence and generativity affordances of digital technologies are pivotal to achieve coaligned digital innovations. As such, we develop a research model based on Nambisan's (2013) framework of IT and product/service innovation. The main propositions include: first, digital technologies can serve as either operand resources that enable coaligned digital innovations or operant resources that trigger coaligned digital innovations; second, digital technologies can serve as either digital tools that affect digital innovation activities or serve as digital components that influence digital innovation outcomes. In what follows, we elaborate these propositions with three sets of research hypotheses.

IT Infrastructure Flexibility and Key Properties of Digital Technology

The key properties of reprogrammability, homogenization of data, and self-referentiality render digital technologies the affordances of convergence and generativity for digital innovations (Yoo et al., 2012). Because the affordances enable recombinatorial innovations based on an interconnected system of collectives, a firm's IT infrastructure, rather than a standalone IS or ICT, is regarded as a better unit of analysis for studying digital innovations (Tilson et al., 2010).

IT infrastructure has been widely studied in the IS literature, referring to the shared set of technical and human IT resources that provide the foundation on which IT applications are run (Byrd & Turner, 2000). IT technical infrastructure consists of computing platforms, communication networks, data, and software components, while IT human infrastructure refers to the technical and managerial skills of IT personnel. Because of hyper-competition, firms increasingly rely on flexible IT infrastructure to perform agile IS activities. This study hence examines IT infrastructure flexibility, referring to the capacity of the firm's IT resources to enable rapid development and implementation of IT applications.

IT compatibility, IT connectivity, and IT modularity has been identified as key properties that make a firm's IT infrastructure flexible (Byrd & Turner, 2000). IT compatibility is the capacity of sharing any type of information across any IT component throughout the firm; IT connectivity is the capacity of any IT component to communicate or be connected with any other IT component, inside or outside of the firm; IT modularity is the capacity to reconfigure and reuse IT components with ease. This study argues that these dimensions of IT infrastructure flexibility embody the reprogrammability, homogenization of data, and self-referentiality properties of digital technology, as discussed below.

Impact of IT Infrastructure Flexibility on Coaligned Digital Innovations

Nambisan (2013) argued that digital technology plays the role of operand resource or operant resource in digital innovations. Operand resources are resources that can be acted upon to obtain support for executing a task. In this case, IS/ICTs represent digital components that provide complementary functionalities to digital innovations. For example, the ATM system serves as a component of the self-service banking innovation. By contrast, operant resources are resources that act on other resources to produce effects. Specifically, IS/ICTs trigger digital innovations through integrating other resources or engaging actors within the innovation ecosystem. For example, Apple provides digital content service by integrating iPhone seamlessly with the iTune application from which music, videos, applications, and books are published and sold by various vendors.

Playing the role of operand resources, IT infrastructure that is flexible to achieve digital connectivity and digital convergence is posited to facilitate greater extents and types of digital innovations. Digital connectivity can reduce communication costs and increase the speed and reach of digital artifacts. As such, IT infrastructure with high IT connectivity allows a firm to create digital innovations more efficiently by recoupling extant computing platforms, communication networks, data, and applications with each other or with external IT resources. Digital convergence means that new types of links between previously unconnected resources or actors can be established digitally (Tilson et al., 2010). Because IT modularity and IT compatibility permit heterogeneous but modularized IT resources to be leveraged to orchestrate new IS products/services based on compatible standards, such IT infrastructure can enable a variety of digital innovations efficiently by means of digital convergence. Hence, we argue

that IT infrastructure flexibility can facilitate the creation of new IS products/services that embody digital products, processes, and business models, thus coaligned digital innovations.

H_1: IT infrastructure flexibility positively influences coaligned digital innovations.

H_{1a}: IT connectivity positively influences coaligned digital innovations.

H_{1b}: IT compatibility positively influences coaligned digital innovations.

H_{1c}: IT modularity positively influences coaligned digital innovations.

Ambidextrous IS Process Innovation and Coaligned Digital Innovations

Despite their affordances of convergence and generativity, digital technologies still need to undergo a series of innovation processes in order to realize digital innovations. Fichman et al. (2014) has identified four stages of digital innovation process : discovery, development, diffusion, and impact. Discovery involves invention and selection of new ideas/technologies; development relates to refining core ideas/technologies by packaging and configuring complementary resources; diffusion requires marshaling organizational resources to deploy and absorb innovations into daily routines; impact includes managing and transforming the ecosystem of a focal innovation for value appropriation. All the stages need to be managed consistently in order to exploit the full potentials of digital innovations.

In the discovery and development stages, digital technologies play the role of operand resources and act as digital tools for developing digital innovations (Nambisan, 2013). Such generativity results from the power of digital technologies' layered modular architecture (Yoo et al., 2012). The layered modular architecture renders reprogrammability by separating function and form and enables homogenization of data by separating content and medium. Moreover, the modules designed in such architecture do not follow fixed product boundaries and hence their use are not known in advance. The creation of digital innovations thus involves the orchestration of an ensemble of product-agnostic components from heterogenous layers that may belong to different design hierarchies. Because changing the ways of discovering and developing IS products/services is evitable to reap the benefits of the layered modular architecture, this study argued that IS technological process innovation can facilitate digital innovations.

In the diffusion and impact stages, digital technologies can play the role of operant resources to engage other resources/actors for deploying digital innovations and value appropriation (Nambisan, 2013). For example, Boland et al. (2007) reported that digital 3D representation tools changed the interactions, roles, and responsibilities of construction firms and thus evoked a variety of concomitant innovations. Dougherty and Dunne (2012) showed that digital technologies transformed knowledge partitioning between actors, leading to radical changes in drug discovery activities. Since digital technologies not only embody innovations but also disrupt existing work practices and knowledge distribution, there is a need to innovate on the governance of IS products/services for control and value appropriation of digital innovations (Tiwana & Konsynski, 2010; Yoo et al., 2012). Therefore, this study also argued that IS administrative process innovation can facilitate digital innovations.

We have suggested that IS technological process innovation is pivotal to leverage the generativity of digital technologies in the discovery and the development stages as well as IS administrative process innovation is evitable for appropriating the value of digital innovations in the diffusion and the impact stages. Because the management of all these stages are necessary to accomplish digital innovations, this study argues that simultaneous innovations on IS technological process and administrative process can improve coaligned digital innovation. Since IS technological process innovation and IS administrative process innovation aim at contradictory objectives (i.e., generativity vs. control), this study suggests "ambidextrous IS process innovation" to capture the phenomenon (Gibson & Birkinshaw, 2004). Hence,

H_2: Ambidextrous IS process innovation positively influences coaligned digital innovations.

Impact of IT Infrastructure Flexibility on Ambidextrous IS Process Innovations

Ambidextrous IS process innovation refers to simultaneous persuasion of IS technological process innovation and IS administrative process innovation. Yoo et al. (2012) indicated that such innovations

manifest in firms' efforts to create or leverage digital platforms for enabling or triggering digital innovations. Therefore, the following develops H3 using digital platform as an illustrative example.

Digital platform refers to "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they operate" (Tiwana et al., 2010, p. 676). As the platform owner, the firm's duty shifts from developing applications to providing platform boundary resources (e.g., software development kit) that support third-party developers' work (Ghazawneh & Henfridsson, 2013). As the third-party developer, the firm develops end-user applications drawing on boundary resources offered by the software platform owner. In either of the roles, firms need to change the IT tools for and the ways of IS development and governance, hence, IS technological process and IS administrative process.

Traditionally, firms utilize general IT tools as well as waterfall model and structural analysis and design methodologies to develop IS applications. On the digital platform, however, a significant portion of IS development tasks shift to the leverage of shared data objects, message exchange protocols, and related services and their governance. Firms may also need to adopt agile methods in order to cope with increased pace of IS development. Because the orchestration of IS applications depends more on integrating digital components exported by third-party developers or software platforms, firms need to ensure that their IT infrastructure can support such generativity by managing, coordinating, and connecting the associated heterogeneous resources and actors. Therefore, when a firm possesses IT infrastructure that has higher degrees of connectivity, compatibility, and modularity, it is doubtless that the firm is better enabled to dynamically mix and match its digital components and tools with those of others for developing IS applications (Kim et al., 2011). Accordingly, this study argues that IT infrastructure flexibility can facilitate IS technological process innovation.

Because IS development activities on the basis of digital technologies are distributed across boundaries of firms, a firm's control over and knowledge about the heterogeneous digital components and ultimate IS applications also can be reduced (Yoo et al., 2012). Hence, firms need to specify regulations in order to govern the arm's-length relationship with other participants of value co-creation. This involves changes of rules and mechanisms of alignment, decision making, cost control, and incentive schemes associated with the digital platform (Tiwana & Konsynski, 2010). Since firms with flexible IT infrastructure are more likely to engage in digital innovations together with heterogeneous actors, they have greater incentives to devise governance mechanisms for appropriating or protecting the value of their digital innovations. Therefore, we submit that IT infrastructure flexibility has positive impact on IS administrative process innovation. As a result, we propose the following hypotheses:

H_3: IT infrastructure flexibility positively influences ambidextrous IS process innovations.

H_{3a}: IT connectivity positively influences ambidextrous IS process innovations.

H_{3b}: IT compatibility positively influences ambidextrous IS process innovations.

H_{3c}: IT modularity positively influences ambidextrous IS process innovations.

This study also includes firm size and IT department size as control variables. Prior research indicated that large organizations possess more diversified knowledge and slack resources; they can also better buffer against financial risks and amortize learning costs (Grover et al., 1997). Both reasons suggest that larger firms or large IT department are better positioned to carry out innovations. Therefore, we adopt both firm size and IT department size as control variables for coaligned digital innovations and ambidextrous IS process innovations.

Conclusions and Implications

This study investigates how and why digital product, digital process, and digital business model innovations can be accomplished simultaneously. Due to the convergence and generativity affordances of digital technologies, digital innovations in the aspects of product, process, and business model are rendered possible and likely to occur concomitantly. Hence, we posit that "coaligned digital innovations" is a pivotal objective to firms seeking to reap the fullest benefits of digital technologies. In addition, we argue that IT infrastructure flexibility (i.e., modularity, compatibility, and connectivity) embodies the

reprogrammability, the homogeneity of data, and self-referentiality properties of digital technologies. Thus, IT infrastructure flexibility, serving as operand resources, is posited to enable coaligned digital innovations through its convergence and generativity affordances. Since exploiting the affordances of digital technologies needs changes in IS development tools/methods while appropriating the value of digital innovation requires the devise of new IS administrative rules/processes, this study further proposes that "ambidextrous IS process innovations" serves as operant resources through which flexible IT infrastructure triggers coaligned digital innovations.

This research offers several potential implications to managers. First, firms that seek to pursue coaligned digital innovations need to enhance the extent of connectivity, compatibility, and modularity of their IT infrastructure in order to render convergence and generativity affordances. Second, firms also need to innovate on their IS development and management activities in order to exploit the generativity of digital technologies while prevent the risks of losing control caused by such generativity.

References

Boland, R. J., Lyytinen, K., and Yoo, Y. 2007. "Wakes of Innovation in Project Networks: The Case of Digital 3-D Representations in Architecture, Engineering, and Construction," *Organization Science* (18:4), pp. 631-647.

Byrd, T., and Turner, D. 2000. "Measuring the Flexibility of Information Technology Infrastructure: Exploratory Analysis of a Construct," *Journal of Management Information Systems* (17:1), pp. 167-208.

Carlo, J. L., Lyytinen, K., and Rose, G. M. 2011. "Internet Computing as a Disruptive Information Technology Innovation: The Role of Strong Order Effects," *Information Systems Journal* (21:1), pp. 91-122.

Dougherty, D., and Dunne, D. D. 2012. "Digital Science and Knowledge Boundaries in Complex Innovation," *Organization Science* (23:5), pp. 1467-1484.

Fichman, R. G., Dos Santos, B. L., and Zheng, Z. 2014. "Digital Innovation as a Fundamental and Powerful Concept in the Information Systems Curriculum," *MIS Quarterly* (38:2), pp. 329-353.

Ghazawneh, A., and Henfridsson, O. 2013. "Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model," *Information Systems Journal* (23:2), pp. 173-192.

Gibson, C. B., and Birkinshaw, J. 2004. "The Antecedents, Consequences, and Mediating Role of Organizational Ambidexterity," *Academy of Management Journal* (47:2), pp. 209-226.

Lyytinen, K., and Rose, G. M. 2003. "The Disruptive Nature of Information Technology Innovations: The Case of Internet Computing in Systems Development Organizations," *MIS Quarterly* (27:4), pp. 557-596.

Nambisan, S. 2013. "Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research," *Journal of the Association for Information Systems* (14:4), pp. 215-226.

Swanson, E. B. 1994. "Information Systems Innovation among Organizations," *Management Science* (40:9), pp. 1069-1092.

Tilson, D., Lyytinen, K., and Sørensen, C. 2010. "Desperately Seeking the Infrastructure in IS Research: Conceptualization of Digital Convergence as Co-evolution of Social and Technical Infrastructures," in *Proceedings of the 43rd Hawaii International Conference on Systems Science*.

Tiwana, A., and Konsynski, B. 2010. "Complementarities between Organizational IT Architecture and Governance Structure," *Information Systems Research* (21:2), pp. 288-304.

Yoo, Y., Boland Jr., B. J., Lyytinen, K., and Majchrzak, A. 2012. "Organizing for Innovation in the Digitized World," *Organization Science* (23:5), pp. 1398-1408.