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Mengmeng Zhang
National University of Defense Technology, 377019128@qq.com

Honghui Chen
National University of Defense Technology, chh0808@gmail.com

Kalle Lyytinen
Case Western Reserve University, kalle.lyytinen@case.edu

PRINCIPLES OF ORGANIZATIONAL CO-EVOLUTION OF BUSINESS AND IT: A COMPLEXITY PERSPECTIVE

Research in Progress

Zhang, Mengmeng, Science and Technology on Information Systems Engineering Laboratory, National University of Defense Technology, China, 18670381635@163.com

Chen, Honghui, Science and Technology on Information Systems Engineering Laboratory, National University of Defense Technology, China, chh0808@gmail.com

Lyytinen, Kalle, Case Western Reserve University, United States, kalle@case.edu

Abstract

The Business and IT Co-evolution (BITC) is a growing concern for researchers and practitioners alike. Extant literature on implementation and management of BITC is still in infancy and lacks especially empirical guidelines. This paper makes two contributions to the study of BITC. First, we summarize and systematically organize 10 BITC principles from prior literature to guide management efforts. Second, we build a system dynamics model based on the 10 principles to apply these principles as a means to improve the BITC management. The model embraces the emergent behaviors driven by the interactions of business and IT, and guides the BITC governance shaped by the principles. The development of this model forms a necessary step towards suggesting guidance how to implement BITC in companies. The paper also shows the capability of a system dynamic method to capture some of the holistic behaviors that emerge from implementing the 10 principles.

Keywords: Business and IT Co-evolution, Alignment, BITC principles, Complexity, System dynamics model.

1 Introduction

Recently, a co-evolutionary theory (Benbya and McKelvey, 2006a; Tanriverdi and Venkatraman, 2010) has been inaugurated to address unsettled issues in business and IT alignment. Much of the past literature underestimates the "emergent complexity" of IT and business interactions (Benbya and McKelvey, 2006a; Tanriverdi and Lim, 2017), largely ignores the informal "bottom-up" learning and adaptations (Ciborra, 2000; Simpson et al., 2016), and one-sidedly emphasizes a single alignment dimension or level (Chan and Reich, 2007). By focusing on continuous learning and adaptations between multiple system components (Ciborra, 2000), the co-evolutionary theory seeks to explain the multi-level, multi-directional, non-linear, and feedback-based relationships between business and IT (Benbya and McKelvey, 2006a; Peppard and Campbell, 2014). The Business and IT Co-evolution (BITC) forms "a continuous co-evolutionary process that reconciles top-down 'rational designs' and bottom-up 'emergent processes' of coherently interrelating all components of the Business/IS relationships in order to contribute to an organization's performance over time" (Benbya and McKelvey, 2006a, p. 284). However, despite a growing research interest, BITC theories remain limited due to a lack of empirical guidance, and their value in explaining dynamics of alignment are still unsubstantiated.

Currently, a majority of BITC research focuses on the clarification of BITC's definition and on the description of the phenomenon (Tanriverdi et al, 2010; Simpson et al, 2016). Due to the dynamic complexity, deviations of intended plans, including technological drifting (Ciborra, 2000), inertia (Besson and Rowe, 2012), IT innovations (Yoo et al, 2012), and unforeseen situations (Benbya and McKelvey, 2006a), are consequences of emergent bottom-up processes initiated by frontline users and managers (Baker and Singh 2015). Yet, the emergent nature rarely has been accounted in the past research (Benbya and McKelvey, 2006a). Some extant studies introduce minimal principles to handle these complex behaviors (Benbya and McKelvey, 2006a; Nassim and Robert, 2010). However, these principles are scattered in the literature and have therefore limited practical value. Moreover, their granularity varies significantly. Furthermore, few papers explicitly unfold proper approaches to systematically use the principles and control BITC (Amarilli et al., 2016, 2017). Thus, practitioners find hard time to convert the scholarly insights of BITC research into managerial practices (Amarilli, 2017). In short, extant research on BITC implementation is inadequate to understand how, where, and when to adapt to unintended deviations during the BITC process (Tanriverdi and Lim, 2017).

Our goal in this paper is to advance the study of BITC by discussing how formal control and informal adaptations can be simultaneously managed as part of BITC process. Our research goals are twofold. First, we identify key BITC principles from the literature and organize them systematically. Second, drawing on these principles, we propose a system dynamics model as a way to describe the holistic dynamics of BITC process. The system dynamics approach, developed by Forrester in the 1950s, helps capture the system level dynamic features of complex systems based on mathematical and computational models, and thus helps frame and understand complexity in focal systems (Senge, 1991). System dynamics is essentially "the study of information-feedback characteristics to show how organizational structure, amplification (in policies), and time delays (in decisions and actions) interact to influence the success of the enterprise" (Borshchev and Filippov, 2004, p. 4). The approach has been widely applied to understand a number of managerial, social, and economic systems (Senge, 1991; Homer and Hirsch, 2006). In our opinion, a systems dynamics model of BITC helps managers understand dynamic behaviors between IT and business activities, provides evidences of the effects of such interactions, and thereby improves BITC related decision-making.

2 Literature Review

In a rapidly digitizing world, the firm's external and internal complexities increase as firms face the challenge of "dancing rugged" markets (Tanriverdi et al., 2010), pervasive digital technologies (Yoo et al., 2012), and a manifold of interdependent relationships (Allen and Varga, 2006). In these situations, the alignment shifts away from equilibria and starts to embrace "emergent complexity" for BITC (Benbya and McKelvey, 2006a). Instead of requiring a fixed solution, significant deviations from intended plans generated by the internal and external changes need to be "captured" and "tamed" (Tanriverdi and Lim, 2017). This shifts the governance principles to identify root-causes of dynamics and to regulate behaviors by experimenting and learning (Benbya and McKelvey, 2006a). BITC is a proactive process to detect complexity in organizations followed by adoption of suitable strategies. If the complexity is low, the company can seek sustainable competitive advantage; if high, the company need to pursue temporary and fleeting advantages in a rugged landscape (Tanriverdi et al., 2010). Deviations from the intended plans can also have beneficial effects - chance events introduce significant non-linear outcomes (Tanriverdi and Lim, 2017). Therefore, practitioners should carefully consider the benefit that IT based continued innovations offer, even though the lead to a temporary misalignment between business and IT (Baker and Singh 2015).

Scholars have attempted to understand BITC using multiple types of research frameworks. Several theoretical BITC frameworks have been formulated using established, coherent explanations of relationships between business and IT based on first principles of theory such as activity theory (Weeger and Haase, 2016). Conceptual BITC frameworks have been put forward using an array of constructs, such as the co-evolution constructs introduced by Amarilli (2016, 2017). Inductive BITC frameworks have been articulated by synthesizing findings from practitioners' insights (Peppard and Campbell, 2014). To validate the proposed frameworks, scholars have introduced several qualitative and quantitative methods. In addition, four main phases of research focus on BITC can be noted: phase A identifies the presence of BITC phenomenon and brings it to the attention of researchers; phase B interprets essential features of BITC; phase C focuses on the improvement of BITC by developing governance principles; phase D is concerned how to achieve certain BITC outcomes. Table 1 summarizes a set of sampled BITC literature organized by applied research framework, methodology used, and the study phases.

Literature	Framework	Methodology	Phases (Ordered by focus)
Mitleton and Papaefthimiou (2000)	Theoretical	Qualitative	A, C, D
Cecez-Kecmanovic and Kay (2001)	Theoretical	Qualitative	A, B
Agarwal and Sambamurthy (2002)	Inductive	Qualitative	C
Peppard and Breu (2003)	Theoretical	Non-Empirical	B, A
Kim and Kaplan (2005)	Theoretical	Qualitative	B
Kim and Kaplan (2006)	Theoretical	Qualitative	B
Benbya and McKelvey (2006a)	Conceptual	Non-Empirical	B, C, A
Benbya and McKelvey (2006b)	Theoretical	Non-Empirical	C, B
Vidgen and Wang (2006)	Conceptual	Non-Empirical	B, A
Allen and Varga (2006)	Conceptual	Non-Empirical	B
Tanriverdi et al (2010)	Conceptual	Non-Empirical	A
El Sawy et al (2010)	Conceptual	Non-Empirical	B, A
Nassim and Robert (2010)	Conceptual	Quantitative	C, D
Zhang et al (2011)	Theoretical	Qualitative	B
Vessey and Ward (2013)	Conceptual	Non-Empirical	B, A
Sandberg (2014)	Conceptual	Qualitative	B, A
Peppard and Campbell (2014)	Inductive	Qualitative	B, C, A
Rai and Tang (2014)	Conceptual	Non-Empirical	B
Baker and Singh (2015)	Theoretical	Non-Empirical	C, B
Simpson et al (2016)	Theoretical	Qualitative	A
Weeger and Ulrich (2016)	Theoretical	Qualitative	B
Amarilli et al (2016)	Conceptual	Non-Empirical	B, A
Amarilli et al (2017)	Conceptual	Qualitative	C, B, D
Tanriverdi and Lim (2017)	Theoretical	Non-Empirical	B, C

Table 1. Classification framework of BITC literature

While Table 1 indicates an increased interest in BITC, a majority of the articles build conceptual or theoretical framework and focus on phase A and B. By introducing some focus on phase C, some scholars have recently put forward ad hoc principles to govern BITC. We will summarize the key findings of this research by synthesizing BITC principles. Additionally, only three papers discuss BITC implementation based on empirical cases (phase D). Yet, these articles tend to emphasize other phases- especially soliciting principles- instead of analyzing a holistically focal BITC implementation. To mitigate this gap, we suggest to use a system dynamics approach to describe holistically the dynamics of BITC implementing process that is founded on a complete set of BITC principles. So far, only one study has used a quantitative analysis to validate the effects of proposed BITC principles (Nassim and Robert, 2010). Overall, the state of the field calls for more research towards guiding the BITC implementation in companies and extracting rational feedback for theoretical research.

3 BITC Principles

The bottom-up adaptation in BITC is important because it helps achieve a harmonious co-evolutionary process of business and IT interactions. The adaptive outcomes of co-evolutionary dynamics rests on governance principles (Benbya and McKelvey, 2006a). For example, Nassim and Robert (2010) proposed a “modular design” principle, which drives a greater speed in developing new or modifying existing applications. A “requisite internal complexity” principle is used to accommodate sufficient variety to adapt to a changing environment (Benbya and McKelvey, 2006b). These principles are often used to explain the concept of BITC, but rarely treated as guidelines for controlling BITC in practice. Meanwhile, the granularity of princpiples varies also significantly. In order to clear the contributions of prior literature, we organize the principles from a complexity perspective and explain it in an applicable way. The traditional alignment mechanisms, such as adding relationships and allocating resources, are excluded from the results. After collecting from the top journals and conferences suggested by the Senior Scholar Consortium of the Association for Information Systems (AIS), we articulate 10 BITC principles as summarized in Table 2. The 10 principles can be directly applied to companies and form a holistic set of guidelines to control BITC. Non-rejecting their incompleteness, we argue that an absence of any principle would increase the risk of reducing evolutionary rates and losing competitive advantages of a company.

No.	Name	Description	Supporting literature
P1	Consider both exploration and exploitation as part of IT strategies.	Exploration concerns to discover new opportunities, and exploitation increases the productivity of existing capabilities.	Peppard and Breu, 2003; Zhang et al., 2011; Vessey and Ward, 2013.
P2	Consider digital IT capabilities as inherent elements of planning business strategies.	IT strategies are no longer subordinate to business strategies but shape them.	Agarwal and Sambamurthy, 2002; Sandberg, 2014; Rai and Tang, 2014.
P3	Adopt modular design.	Modularity is the ability to easily reconfigure components by minimizing interdependencies among modules.	Benbya and McKelvey, 2006a; Benbya and McKelvey, 2006b; Nassim and Robert, 2010.
P4	Adopt suitable organizing principles.	An organization should balance the internal coordination and external partnering.	Agarwal and Sambamurthy, 2002; Vidgen and Wang, 2006; Amarilli et al., 2017.
P5	Communicate frequently among agents.	Agents should communicate with each other and form a collaborating relationship.	Allen and Varga, 2006; Peppard and Campbell, 2014; Baker and Singh, 2015.
P6	Share domain knowledge.	Agents build consensus as to the shared reality of the organization.	Allen and Varga, 2006; Peppard and Campbell, 2014; Simpson et al., 2016.
P7	Detect and sense deviations from intended plans.	Firm need to sense and respond to external or internal changes in a timely manner.	Sandberg, 2014; Weeger and Ulrich, 2016; Tanriverdi and Lim, 2017.
P8	Conduct root-cause analyses.	Root causes should be identified on the basis of multiple symptoms.	Benbya and McKelvey, 2006b; Weeger and Ulrich, 2016; Tanriverdi and Lim, 2017.
P9	Add mechanisms and learn from environmental reaction.	Mechanisms should be added to analyze its reactions to dynamic actions.	Benbya and McKelvey, 2006a; Tanriverdi et al., 2010; Tanriverdi and Lim, 2017.
P10	Predict possible emergent situations in advance.	Possible emergent situations should be examined to speed up future change rates.	Vessey and Ward, 2013; Amarilli et al., 2016; Amarilli et al., 2017.

Table 2. Ten BITC principles

The 10 principles were elicited in the following way. Six out of ten principles were identified by taking into account three alignment dimensions. The strategic dimension refers to the degree the business strategy and IT strategy complement with each other; the structural dimension refers to the degree of structural fit between IT and the business; the social dimension refers to the degree to which business and IT executives understand and are committed to business and IT mission, objectives, and plans (Chan and Reich, 2007). Specifically, along with the strategic dimension, P1 suggests that the co-evolution needs to be ambidextrous and consider exploration and exploitation as part of IT strategies (Peppard and Breu, 2003). Value creation can be pursued through IT strategies of exploration and exploitation (Peppard and Breu, 2003). Being consistent with research of digital business strategy, P2 considers digital IT capabilities as inherent elements of planning business strategies (Kahre et al., 2017). According to Bharadwaj (2013), it's time to rethink the role of IT strategy, from that of a functional-level strategy to one that reflects a fusion between IT strategy and business strategy. Considering the structural dimension, adopting modular design (P3) is often favored because it offers a way to reconfigure technology components easily (Benbya and McKelvey, 2006a). Additionally, BITC needs to adopt suitable organizing principles (P4) (either centralized, decentralized, or federal) to manage business processes (Agarwal and Sambamurthy, 2002). BITC demands communicating frequently among agents (P5) and sharing their domain knowledge (P6), which are two beneficial principles from the social dimension (Peppard and Campbell, 2014). These two principles are also favored by traditional alignment research. The rest four principles are drawn from research on misalignment analysis (Carvalho and Sousa, 2008). The misalignment analysis focuses on misalignment detection, correction, and prevention, and forms the main process of the co-evolution. Companies need to first detect and sense deviations of intended plans (P7) (Baker and Singh, 2015), and then conduct root-cause analyses (P8) to investigate the reasons behind the scene (Benbya and McKelvey, 2006b). To adjust these deviations and to avoid further misalignment, companies need to add mechanisms and learn from environmental reactions (P9) (Tanriverdi and Lim, 2017). These mechanisms are adjusting actions companies adopt, such as the dynamic resource allocation. Adapting with the reactions, these deviations need to be "tamed" instead of "solved". Furthermore, with the intelligence capability (Nan and Tanriverdi, 2017), companies need to predict emergent situations in advance (P10) (Benbya and McKelvey, 2006a), in order to increase companies' internal complexity and to accelerate future change rates. Overall, to coordinate top-down control and bottom-up adaptation, the above principles are not only summarized from the view point of alignment dimensions, but also refer to the misalignment analysis. In this regard, the principles seek to "tame" the emergent behaviors forming part of the BITC process so as to benefit the company's performance.

4 A System Dynamics Model of BITC

To ensure that principles can be systematically utilized in BITC implementation (phase D in Table 1), we adopted a system dynamics model to develop their effects. Such model is used to explain nonlinear behaviors, to simulate complex interactions, and to provide practical insights to the emergent system level behaviors. In our case, such a model is employed to describe how the principles are followed and what are their effects during the BITC process. The system dynamics model is founded on the following rules (Senge, 1991): 1) it includes a considerable number of interacting variables that change over time; 2) the interaction drives system behaviors; 3) the behaviors are characterized by reinforcing and balancing loops; 4) the system is characterized by the accumulation of "stocks" which include people, information, and material resources. Two recent BITC articles have introduced system dynamics models. Peppard and Campbell (2014) formulate such a model by synthesizing practitioners' experiences. Baker and Singh (2015) explain how and why the misalignment between business strategies and IT strategies occur from a system dynamics perspective. In their argument, BITC is reflected in the process of realizing intended business and IT elements. These articles emphasize the social alignment dimension, instead of considering a complete set of BITC principles that deal with IT capabilities, governance, and so on. Therefore, we seek to integrate the 10 principles of BITC process with a more complete system dynamics model. Due to the complex relationships between business and IT elements, we also introduce a configuration method to evaluate the holistic performance of a company as schematically illustrated in Figure 1[1].

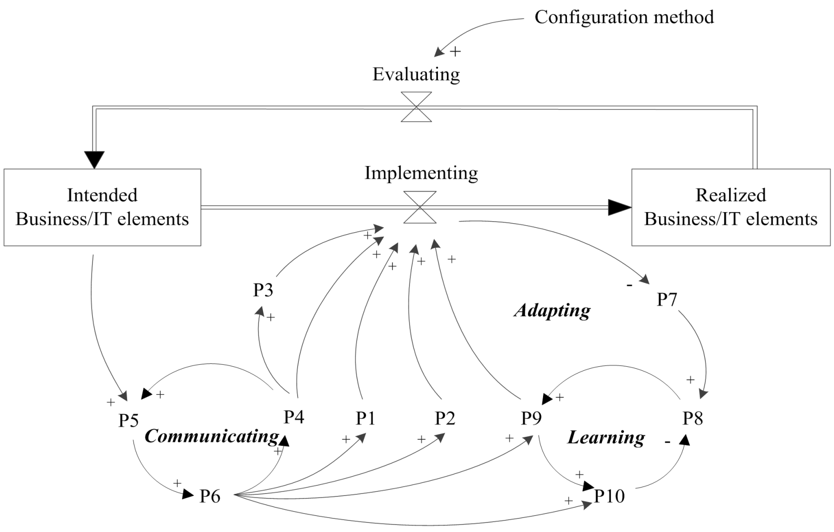

Figure 1. A system dynamics model of BITC

In Figure 1, the "Intended Business/IT elements" and "Realized Business/IT elements" are denoted as stocks (indicating the level of a variable). The interaction of business and IT elements drives the evolution of a company. These stocks may include any elements in strategic, operational, or individual levels (Benbya and McKelvey, 2006a). We do not distinguish the business and IT elements but treat them as a holistic system due to their nonlinear interdependence. Generally, the "Intended Business/IT

[1] Due to the page limit, we cannot explain the model in great detail on every relationship. Instead, we organize the relationships based on the feedback loops in this model.

elements" are likely to achieve a higher mutual-alignment in the initial strategic planning stage. However, because possible deviations occur during implementation (Benbya and McKelvey, 2006a; Baker and Singh, 2015), the co-evolution emerges to help discover causes and tame deviations. As a result, the "Realized Business/IT elements" should be determined by whether their current combination will improve company performance. The "Implementing" and "Evaluating" processes symbolize flows (rates and directions of change). The levels of the two stocks are continuously changed based on the two flows. Furthermore, the flows are affected by control factors and the relationships among them, which include positive relationships (i.e. "+" sign, for example, a clear communication among agents increases the likelihood that they will share domain knowledge) and negative relationships (i.e. "-" sign, for example, increasing emergent issues occurred in the "Implementing" process may hinder the detection of deviations).

The control factors and their relationships help achieve reasonable top-down control and bottom-up adaptation in the "Implementing" process. Specifically, a clearly articulated "Intended Business/IT elements" will increase efficiency of communication (P5) (Baker and Singh, 2015). The desire to communicate among individuals (P5) facilitates the development of mutual trust and thus benefit domain knowledge sharing (P6) (Allen and Varga, 2006). The shared knowledge motivates the adjustment of organization structure to an optimal condition (P4) (Mitleton-Kelly and Papaefthimiou, 2000; Zhang et al., 2011), as well as the consideration of exploration and exploitation strategies (P1) (Kim and Kaplan, 2005; Zhang et al., 2011) and the combination of business strategies and IT strategies (P2) (Peppard and Campbell, 2014; Baker and Singh, 2015). Meanwhile, the shared knowledge (P6) is beneficial to learn the reactions (P9) from external and internal environments (Zhang et al., 2011). Agarwal (2002) and Amarilli (2017) argued that the adjusted organization structure will conversely make communication easier among individuals (P5). Thus, a reinforcing loop, labeled as "Communicating", is formed among P4, P5, and P6. This loop continuously mitigates contradictions and builds consensus among individuals over time. Additionally, with regards to the principles of P3 and P4, we argue that a coordinated organization model (P4) facilitates the adoption of the modular design (P3) rule (Tanriverdi et al., 2010; Amarilli et al., 2017). Based on the literature, the "Implementing" process is positively affected by modular design (P3) (Benbya and McKelvey, 2006a; Nassim and Robert, 2010), a structural organizational fit (P4) (Agarwal and Sambamurthy, 2002; Amarilli et al., 2017), ambidexterity of exploration and exploitation (P1) (Peppard and Breu, 2003; Vessey and Ward, 2013), and a coalescence of business and IT strategies (P2) (Sandberg, 2014; Kahre et al., 2017).

Meanwhile, unpredictable external changes, unintended events, failed promises, and human errors (Benbya and McKelvey, 2006a) may occur during the "Implementing" process. The emergence of such deviations increases the difficulty of their detection (P7) (Baker and Singh, 2015; Tanriverdi and Lim, 2017). According to the misalignment analysis research, the deviations can be mitigated through two steps. First, it is necessary to analyze the root-causes of the deviations (P8) (Benbya and McKelvey, 2006b; Baker and Singh, 2015), and second, it is required to capture system reactions after adding adjustment mechanisms (P9) (Amarilli et al., 2017; Tanriverdi and Lim, 2017). It is worth noting that correcting the deviations is not an imperative, instead organizations can select an eclectic strategy to avoid further misalignment. These attempts will positively influence the "Implementing" process (Amarilli et al., 2017; Tanriverdi and Lim, 2017). A balancing loop labeled "Adapting" is formed among P7, P8, and P9 in the "Implementing" flow. This loop tames the deviations with appropriate managerial mechanisms to cultivate a harmonious business and IT relationship. Similarly, prevention mechanisms can be accumulated after the deviations are adjusted (P9). Exploring possible emergent situations in advance (P10) makes possible to better confront future changes (Tanriverdi et al., 2010; Amarilli et al., 2017). According to Vidgen (2006) and Rai (2014), emergent situations (P10) can be predicted by sharing knowledge among individuals (P6). Increasing level of emergent situations will raise the internal complexity of organizations and result in higher complexity in the root-cause analyses (P8) (Benbya and McKelvey, 2006b; Baker and Singh, 2015). Hence, P8, P9, and P10 form a balancing loop labeled "Learning", which helps the organization to continuously explore and understand emergent events. Overall, the above three loops act as wheels that drive the "Implementing" process move forward smoothly.

It is likely that the "Realized Business/IT elements" would be differ from the "Intended Business/IT elements" as a result of executing the BITC principles in the "Implementing" process. The company's performance need to be evaluated with the combination of realized elements. If it does not perform well, the "Intended Business/IT elements" need to be adjusted and implemented again. We use a configuration method to evaluate the performance. The configuration method views system elements as combinations, which are evaluated as a holistic integrated pattern accommodating complex interconnectedness of multiple elements, nonlinearities, and discontinuities (El Sawy et al., 2010; Fiss, 2011). We apply the configuration method to the system dynamics model in order to examine the current combination of business and IT in a holistic way. In addition, because configuration method has the ability to assess the importance of each component in the combination, it can also be used to update the "Intended Business/IT elements." In this way, a feedback loop is also established between the "Implementing" and the "Evaluating" flow, and the loop continuously adjusts the stock levels of "Intended Business/IT elements" and "Realized Business/IT elements". The loop overall explains the evolutionary dynamics of business and IT interactions.

Noteworthy, the above principles and the relationships among were mainly extracted from the extant research achievements, which need to be validated in a more detailed way. This model embraces other reasonable elements and relationships, in order to make the model more persuasive and guidable. In summary, the model describes a set of multi-level, multi-directional, non-linear, and feedback relationships between business and IT. It is not meant to align business and IT elements invariably, but rather to seek a holistic co-evolutionary solution for their interactive principles. The gap between business and IT is filled over time, and ultimately the two form a holistic and complex system. Additionally, emergent adaptation is mainly addressed by taming deviations. Furthermore, the model is proactive to the extent that it can sense deviations, adopt appropriate strategies, and evaluate outcomes iteratively. Consistent with the characteristics of BITC, the model integrates 10 principles guiding the implementation of BITC, and can be used as a basis of further empirical inquiry.

5 Conclusion

We contribute to the extant BITC literature in two ways. First, we summarize the BITC principles and organize them in a systematic way. These principles help tame the unintended deviations of IT and business alignment. Second, the system dynamics model, composed of a comprehensive set of BITC principles and considered a configuration method, accounts for the changing stock levels of intended and realized elements of the business/IT landscape. The system dynamics model acts as a top-down model to seek for the fitness landscape of coevolution. With the articulation of the principles' effects in the BITC process, the further bottom-level analysis should be conducted in the future to complement the emergent adaptation.

BITC has become a major concern for practitioners (Amarilli et al., 2016, 2017). To better manage BITC in organizations, the introduced 10 principles can be systematically applied in a dynamic framework to influence the BITC trajectory. The model is essentially a sensemaking conceptual map that exhibits internal logic of BITC process. In addition, given that the majority of BITC research focuses on theoretical analysis, we argue that the development of a system dynamics model forms an important step towards practical application.

In summary, this paper aims to extend the extant BITC research and to provide BITC guidelines for companies. Our future research direction mainly concerns the following aspects. First, since BITC is an emerging research field with a small volume of studies, the 10 principle in building the system dynamics model may be insufficient. It is important to validate the effectiveness of the extant principles and their relationships. The corresponding propositions and validating methods should be introduced. At the same time, we will test whether it is necessary to include any other principles.

Second, from a system dynamics perspective, we only examined the conceptualization and formulation stages of BITC process in this paper, without addressing the testing and implementation stages (Luna-Reyes and Andersen, 2003). Specially, a classic challenge in the usage of system dynamics model (Coyle, 2000; Luna-Reyes and Andersen, 2003) is additional data collection and analysis to validate the model. We will consider several data collection methods (e.g., interviews, oral history, focus groups, observation, and experimental approaches) and analysis methods (e.g., discourse analysis, grounded theory, and content analysis) (Luna-Reyes and Andersen, 2003). According to Coyle (2000), the data (e.g., parameters, time delays, and mathematical equations) are expected to fit the model as close as possible, otherwise the model will be "plausible nonsense."

Third, the model needs to be applied to real cases to see if it is able to satisfy requirements concerning its realism, robustness, flexibility, clarity, sensitivity and ability to generate useful insights (Homer and Hirsch, 2006). Through operating the system dynamics model, organizations will be better able to control BITC trajectory, and particularly to make decisions of the evolutionary process. The practical experiences will provide feedback for further theoretical research.

The fourth considers other complementary models. The system dynamics approach is a high-level method addressing complex behaviors in a holistic way. Other models with lower abstraction and more detail can be considered as alternatives to understand individual behaviors. Here, agent-based models (ABM) describe behaviors on an individual level, while organizational behaviors emerge as a cumulative outcome of individual behaviors. Acting as a "bottom-up" modeling method, ABM can be adopted to integrate with the system dynamics model. In that case, the integrated model will be able to capture detailed real-life phenomena (Borshchev and Filippov, 2004) and generate micro controls for detailed decision-making within BITC.

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