Co-evolution in Business Ecosystems: Findings from Literature

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Abstract: The innovative use of digital technologies has led to a disruption of well-established business models in many industries. To prevent from being disrupted, organizations must transform. However, studies about digital transformation have primarily focused on intra-organizational dynamics, including processes, structures, and business models. Digital transformation, however, substantially changes inter-organizational behavior, sometimes the entire ecosystem. To examine this phenomenon, we draw on co-evolution theory, which states that changes occur among all interacting organizations, permitting transformations to be driven by both direct interactions and ecosystem feedbacks. Thus, goal of this paper is to provide a structured overview of literature about the co-evolution of ecosystems in management, organizational science, and IS literature. Following the six properties of co-evolution, we develop a framework for the co-evolution in ecosystems, comprising 23 configurations, based on the analysis of 44 articles. Ultimately, we suggest avenues for future research.

Keywords: ecosystem, co-evolution, literature review, digital transformation

1 Motivation

Digital platforms having the capacity to combine and deploy innovative technologies create the potential to radically change the way organizations do business in their respective ecosystems. This sometimes leads to a disruption of well-established business models [RT14]. We refer to the organizational transformation to prevent a disruption through the innovative use of digital technologies as digital transformation [WW15, Ri19]. Studies about digital transformation have been primarily concerned with an intra-organizational perspectives, including processes, products, services, organizational structures, and business models [see, e.g., KW15, KHH15]. Digital transformations substantially influence inter-organizational partnerships, particularly in business

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ecosystems, where value is co-created among multiple stakeholders [Sa12, Ce14, Ri18b]. Thus, partnerships are increasingly important, because the market for information technology (IT) is constantly evolving and giving rise to a variety of innovations, e.g., cloud computing, in-memory databases, blockchains, and distributed ledgers [Os18]. These are often provided in platform ecosystems, comprising specific digital platforms and applications and their stakeholders, owners, and complementors [Ti14, Ri18a]. In such ecosystems, we understand that platform owners represent the legal entity owning the platform [Ti14]. Complementors contribute additional value to the platform in the form of applications [Ti14]. Furthermore, platform owners rely on partners to gain access to customers or complementary resources and capabilities [Sa12, LN15]. To study the ongoing digital transformation from an ecosystem perspective, we view the problem through the lens of co-evolutionary theory. This theory assumes that changes can occur at all interacting organizations, permitting transformation to be driven by both direct interactions and positive feedback [LV99, MHG14]. Thus, we analyze the extant literature on co-evolution in IS, management, and organization science literature to build a comprehensive understanding for co-evolution in ecosystems. Second, based on the six propositions of Montealegre et al. [MHG14], we suggest a framework for the co-evolution in ecosystems, including 23 configurations for these propositions. Ultimately, we suggest avenues for future research. This paper is structured as follows. First, we present our conceptual background and research method. Second, we provide an overview of co-evolution theory in literature, particularly in ecosystems. Third, based on the literature review, we propose a framework for co-evolution in ecosystems and suggest avenues for future research. After discussing our results, we conclude with limitations and implications.

2 Digital Transformation in Business Ecosystems

Many digital transformation articles have built upon transformations caused by digital technologies [e.g., Fi14]. Following Yoo, Henfridsson and Lyytinen [YHL10], a new organizational logic is necessary to cope with digital innovations [YHL10]. The case of Kodak shows that new organizational logic is very difficult to achieve, particularly when an organization’s business model has been successful for more than a century [LG09]. Using digital technologies, potential co-creation in ecosystems has become easier via the supply of boundary resources [GK12]. As an example, Apple provided a digital platform to distribute iOS applications. Because most of these applications were developed by third parties, developers were forced to learn a specific programming languages and co-evolve their development processes with Apple [Ea15]. Apple supported third-party developers heavily via the supply of boundary resources [Ea15]. Apple relies heavily on co-creation in its ecosystem, which plays a major role in successful digital transformation [Sa12]. However, whereas Apple’s partners gained access to a huge customer base, they were critically affected by the digital transformation. Therefore, if digital transformation implies the introduction of a digital platform, the business models of co-creating partners are affected. Riasanow, Galic and Böhm [RGB17] demonstrated that emerging players who build mobility service platforms induced a substantial transformation of the automotive ecosystem. For ecosystems, three terminologies are commonly used, dividing the field into three broad streams, as found by Jacobides et al. [JCG18]. These terms are business ecosystems, innovation ecosystems, and platform ecosystems. The three streams differ in their foci, but they share the common understanding of ecosystems as a group of interdependent firms. In a hierarchical sense, business ecosystem can be seen as the root, being explored first, with innovation and platform ecosystems derived thereafter. According to Moore [Mo93], business ecosystems comprise entities with co-evolving capabilities around new innovations in a cooperative and competitive way. These entities represent an economic community supported by a foundation of interacting organizations and individuals that produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders [Mo93]. An innovation ecosystem is a business ecosystem that focuses on the solution for the end customer. A concise definition for innovation ecosystems is the "collaborative arrangements through which firms combine their offerings into a coherent customer-facing solution" [Ad06]. In some articles about business ecosystems, the term "platform" is already mentioned, as in the conceptualization of Autio and Thomas [AT14]. Business ecosystems are more generic, of which platforms are the common instantiation. Many business ecosystems, such as Apple iOS ecosystem, have, at their core, a platform that structures and orchestrates complementors and partners [Ea15]. In this work, we use the terms, "business ecosystem" and "platform or innovation ecosystems" as specific instantiations of business ecosystems. Following Jacobides et al. [JCG18], there is broad knowledge on what ecosystems are. However, we still have limited knowledge about their digital transformation. Co-evolution, first recognized in the field of biology, occurs when two or more species reciprocally affect one another's evolution [CHL91, VW13]. When a system evolves to ensure its best fit, its environment also changes, and those changes are likely to result in further system changes, resulting in continuous system change [VW13]. Therefore, we draw on the theoretical lens of co-evolution to examine this phenomenon.

3 Research Approach

Our work follows a four-step research approach. To identify existing literature contributing to the co-evolution in business ecosystems, we conduct a structured literature review following Webster and Watson [WW02]. In the first step, we focus on leading outlets of IS, management, and organization science, (i.e., the AIS Senior Scholars' Basket of Journals and FT50 journals). Using the EBSCOhost and Scopus databases, we apply the following search terms to the titles, abstracts, and keywords: ("co-evolution" OR "co-evolution") AND ("ecosystem" OR "network"). The search was conducted between May and August 2018. Following Okoli and Schabram [OS10], we reviewed the articles manually and filtered them according to an iterative set of exclusion criteria. Thus, articles not addressing co-evolution in ecosystems, such as Helfat and Raubitschek [HR00], were removed, resulting in 27 selected articles. For the second step, we extended our search to conferences to include recent contributions since 2000. This yielded another 17 articles, resulting in 44. See Table 1.

Outlet		**Hits**	**Selected articles**
IS Journals	Information Systems Research	6	[RT14, GGA11, TRV10, TKB10, VW09, Sa10]
	Journal of the Association for Information Systems	3	[MHG14, VW13, Pu10]
	Journal of Management Information Systems	1	[FN09]
Management and Organization Science Journals	Research Policy	6	[AC01, CV08, HBH04, Ku01, Mu02, Ma13, Mi07]
	Organization Science	6	[An99, DA99, KL99, Mc99, PYH18, SCK10]
	Long Range Planning	3	[Am09, HGB18, Li10]
	Organization Studies	1	[En12]
	Technological Forecasting and Social Change	1	[KTR13]
Top Conferences	International Conference on Information Systems	9	[AC16, AVH17, CA15, HLY17, Hu17, UY16, BPA15a, Ng17, TL17]
	Hawaii International Conference on System Sciences	3	[ST17, SWS18, AZC17]
	European Conference on Information Systems	3	[BAP15b, DC15, WU16]
	Americas Conference on Information Systems	2	[Ja17, HSS16]
Grand Total		**44**	

Tab. 1: Selected Articles on the Co-evolution in Ecosystems

In the third step, we draw upon the six properties of co-evolution identified by Montealegre et al. [MHG14]. Three experienced raters independently coded the selected articles. Before the raters began coding the articles, they coded several other articles to become familiar with the scheme. Then, they calibrated their procedure. All authors validated the coding of each article and discussed the discrepancies until consensus was reached. This helped eliminate disparities [BT90].

4 Literature on Co-evolution in Business Ecosystems

Montealegre et al. [MHG14] identified six properties of co-evolution theory, which we used to structure our findings.

4.1 Multilevel Effects

Co-evolutionary effects vary across a range of multiple levels of analysis [KL99, LL99]. Each level offers a different perspective on co-evolution. We found nine different levels in the articles. Five were intra-organizational levels, including business process, structure, leadership, culture, and business model. Four were inter-organizational levels, including partners, customers, regulatory environment, and other industries. Vidgen and Wang [VW06] found that co-evolution in agile software development between the business process and structure level can be successful if organizations match the co-evolutionary change rate, maximize self-organization, and balance exploration and exploitation. Lin et al. [Li10] characterized the co-evolution in ecosystems based on exchanges of technology via institutional ties. In a single longitudinal case study of a professional service network in the public accounting industry, a network was intentionally created and formally organized to pursue co-evolving effects for the member organization [KL99]. Co-evolution was also successful at another level, as Höyssä et al. [HBH04] showed in an investigation into the level of interaction between the city and its national and international region, focusing on the city's industrial policy as the mediator industry.

4.2 Multidirectional Causalities

Montealegre et al. [MHG14] understood co-evolutionary effects not as a simple cause–effect logia of linear relations between independent and dependent variables. Instead, they ascertained that co-evolutionary process could have many causes [DV09]. A co-evolutionary effect can, in turn, cause many co-evolutionary effects [Li10]. We refer to multidirectional causality between two configurations (i.e., cooperation and competition). In the studied articles, cooperation was understood as voluntary, for which two or more entities could co-evolve in a mutually beneficial exchange instead of competition. Cooperation in the context of co-evolution can happen where resources adequately exist for both parties or are created by their interaction [RT14, Mu02, JD17]. Based on our findings, competition was observed as a rivalry of competencies, resources, profits, market shares, quality, service, rights, knowledge, partnerships, and IT [KL99, Mc99, AC16, AVH17]. Some scholars argued that co-evolutionary processes could combine the configurations of both competition and cooperation [PYH18, HGB18, Li10].

4.3 Nonlinearity

Cause and effect of change in co-evolutionary relationships often did not follow a simple linear logic. However, dependent variables were often influenced by complex interactions of influencing variables. A small change in the initial variables could lead to very significant changes of outputs and even chaotic consequences [VP95]. We suggest a configurations of "diffusion nonlinearity", "hierarchical nonlinearity", and "network nonlinearity" for the co-evolution of business ecosystems and networks in a context characterized by uncertainty following the study of Rogers [Ro95]. Hierarchical nonlinearity occurs when co-evolutionary dynamics follow a vertical direction through an organization or ecosystem. Volberda and Lewin [VL03] defined “hierarchical renewal” as an engine of co-evolution in multi-unit organizations, where the changes cascade down from the top management. In the opposite direction, McKelvey [Mc99] argued that change could be hierarchically propagated from the bottom as chain of competences toward the top throughout the organization. Lin et al. [Li10] found that bottom-up technologies and top-down institutions drove collaboration between organizations, leading to an inter-network and a co-evolution. The co-evolution of complex adaptive systems occurs via nested hierarchies containing more sub-systems, subject to evolutionary dynamics [An99]. Top-down dynamics are observable in governmental organizations, based on a study of disaster-relief ecosystems [ST17] and another on the sphere of healthcare in the hierarchical structure of hospitals [GGA11].

We refer to network nonlinearity for nonlinear-but-orchestrated developments among ecosystem entities. Co-evolutionary dynamics in inter-organizational networks act in nonlinear ways (e.g., jolts, step functions, and oscillations [MGC05]. However, network structures between organizations can emerge in the absence of an authoritative entity. Their creation and development are generally influenced by the actions of an orchestrating entity [PH13]. In the context of a professional services organization network, co-evolution is orchestrated from a headquarters entity that coordinates and facilitates the network exchange [KL99]. It can also be led from the context of innovation policy making the orchestration role less required [Ku01]. From the context of ecosystems, nonlinear diffusion is observed in the form of the diffusion process of technology standards among network members [En12]. Similarly, innovations are diffused in ecosystems among suppliers, end users, and new entrants [HGB18], and they are sparked by spillover effects [Mu02]. Similarly, Bhattacharya et al. [BPA15] analyzed diffusion processes of content postings in social-media networks, where diffusion was mentioned in a different sense, as a formalized process for technology transfer out of the organization [AC01] or as an institution for that specific purpose [CV08]. Some argued nonlinear dynamics went beyond the three identified configurations. A spiral process of co-evolution was detected by van den Ende et al. [VP95]. Kuhlmann [Ku01] uncovered a revolution of innovation. Further, nonlinearity was also used to explain why organizations were unable to renew their offerings in a radical, big-bang approach, in the context of a digital ecosystems of small and medium enterprises (SME) [CA15].

4.4 Mechanisms for Positive Feedback

Positive feedback was described by Lewin and Volberda [VL03] as actions and interactions between entities undergoing recursive co-evolution, leading to recursive interdependencies [Mo93]. A rich variety of positive feedback mechanisms was identified in the selected articles, which we organized into three configurations: “capabilities”, “architectural decisions”, and “managerial actions”. Organizational capabilities can enable co-evolution, including capabilities for customization and standardization of IT to create and appropriate value in co-evolutionary processes [AC16]. In the context of cross-border organizational integration, mechanisms for the co-evolution of capabilities with the organizational structure were depicted by Ambos et al. [Am09], including an integration action plan, an introduction of routines for alignment and standardization, and the development of a knowledge broker for bidirectional knowledge transfer. Positive feedback was also operationalized via architectural decisions of the platforms in ecosystems [KL99]. For software platforms, the decisions on platform openness, architectural decomposition, and modularity were the central levers alongside governance and decision rights mechanisms shaping their co-evolutionary growth dynamics [TKB10]. For the co-evolution of SMEs and their respective ecosystems and environments, Dehbokry and Chew [DC15] suggested a reference architecture that incorporated different views covering strategy, capabilities, and knowledge alongside contingencies with other institutions and the macro environment. Another mechanism used to strengthen the co-evolution was managerial actions, including exclusive agreements for ecosystem members, who legally govern the collaboration and co-evolution of the organizations [AVH17]. Holgersson et al. [HGB18] found that, in the context of an intellectual property strategy, mechanisms for supporting co-evolution included the coordination of working-group networks, cross-licensing agreements for technology accessibility across organizational boundaries, and technical standardization as a governance tool [VW09].

4.5 Path and History Dependencies

The circumstances and conditions in which co-evolutionary processes occur are determined by unexpected events with uncertain outcomes [En12]. Addressing these conditions in a co-evolutionary environment requires following a path having a history of dependencies [MHG14]. Circumstances causing or helping co-evolutionary conditions can be both exogenous and endogenous to the industry, individual organizations, and the ecosystem [KL99]. Therefore, decisions regarding a path-dependent course will influence future actions, strategies, and objectives [Am09] to offer compliance with changes in the ecosystem [Gr12]. The changes in circumstances over time create a history of dependency, shaped by the changing conditions of the evolutionary path and the legacy actions and decisions used to address them [VW13], i.e., ‘legacy’. Because of the individual history and path dependencies among the co-evolving organizations, they develop their own individual capabilities to differentiate their historical evolution paths [TRV10]. Lin et al. [Li10] postulated that the co-evolution between two networks included general environmental shifts and endogenous communications needed to build inter-dependencies and mutual transformations. These dependencies could also be influenced by an extant community with inter-organization collaborations influenced by their prior capabilities [RT14] or networks shaping choices and paths [Mu02]. Specific path dependencies, over time, can develop a beneficial outcome for an organization and ecosystem [Am09], supplemented by organizational socio-technical capabilities [DC15, LL99]. However, organizations with no legacy start-ups may conduct co-evolution as a “greenfield” approach.

4.6 Technology

Montealegre et al. [MHG14] described technology as both an external and internal force, influencing decision making within a business ecosystem or environment. Extending this notion, we found three configurations of technology in co-evolution: disregarded, supported, and enabled. In some articles, technology was not detectable as a driver for co-evolution and was disregarded [e.g., DA99]. As a supportive technology role, Hukal [Hu17] argued that the introduction of new technologies acted as a proxy for co-evolution. Technology can also help to mobilize the transformation of customers in the ecosystem [HLY17]. Digital platform technologies can also support the transformation of end-users to value-co-creators [SWS18]. Um and Yoo [UY16] introduced the most recent property of technology as an "enabler", leveraging characteristics to be changed without restraining the use of existing technologies. Instead, it could enhance the use of different fields by promoting the construction of novel growth patterns in a focal platform system. This was also shown by Janze [Ja17], where blockchain technology enabled the co-evolution of darknet platforms through the usage of cryptocurrencies.

<table>
<tr><th>Property</th><th colspan="60">Configuration</th></tr>
<tr><td rowspan="4">Multilevel effects</td><td colspan="60">Intra-organizational levels</td></tr>
<tr><td colspan="12">Business processes</td><td colspan="12">Structures</td><td colspan="12">Leaderships</td><td colspan="12">Cultures</td><td colspan="12">Business models</td></tr>
<tr><td colspan="60">Inter-organizational levels</td></tr>
<tr><td colspan="15">Partners</td><td colspan="15">Customers</td><td colspan="15">Regulatory environment</td><td colspan="15">other industries</td></tr>
<tr><td>Multi-directional causality</td><td colspan="30">Cooperation</td><td colspan="30">Competition</td></tr>
<tr><td>Nonlinearity</td><td colspan="15">Diffusion</td><td colspan="15">Hierarchical</td><td colspan="15">Network</td><td colspan="15">Big bang</td></tr>
<tr><td>Mechanism for positive feedback</td><td colspan="20">Capabilities</td><td colspan="20">Architectural decisions</td><td colspan="20">Managerial activities</td></tr>
<tr><td>Path and history dependency</td><td colspan="30">Greenfield</td><td colspan="30">Legacy</td></tr>
<tr><td>Technology</td><td colspan="20">Disregarded</td><td colspan="20">Support</td><td colspan="20">Enabler</td></tr>
</table>

Tab. 2: Properties and Configurations of Co-evolution in Business Ecosystems

5 Discussion and Future Research

Through our review of IS, management, and organization science literature on co-evolution processes in ecosystems, our work provided a structured overview of the field from a transdisciplinary perspective. Second, we developed a framework for co-evolution in business ecosystems based on the six properties offered by Montealegre et al. [MHG14], comprising multilevel effects, multidirectional causalities, nonlinearities, mechanisms of positive feedback, paths, and historical dependencies. Furthermore, we extended Montealegre et al. [MHG14] using the property technology, identifying 23 configurations. Second, based on our discussion of the properties and configurations of co-evolution, we provided avenues for future research.

This study has limitations. First, the identified articles are limited to our search terms and the selected articles. Second, this work is limited by the coding of the articles to their respective co-evolution properties and configurations. To mitigate these limitations, three experienced raters coded the articles independently. We ensured that a broad amount of co-evolution articles was included by opening the search to conference articles.

Based on this study, four theoretical contributions came to light. First, the findings of our structured literature review about the identified configurations showed that co-evolution materialized in different ways in different business ecosystems. Therefore, the study enlarged the literature of Lewin and Volberda [LV99] and Montealegre [MHG14]. Second, we fused insights from IS, management, and organizational science and built upon the proposition of Jacobides [JCG18] to contribute a theory about ecosystem transformation by suggesting the notion of co-evolution. Third, our findings showed that co-evolution in business ecosystems was dependent of new properties, which are particularly evident because of the emerging role of technology. Fourth, we showed that co-evolution was a suitable lens for examining digital transformation from an inter-organizational perspective.

This study provided two practical contributions. First, we invited practitioners and scholars to apply the identified configurations to the properties of co-evolution when discussing digital transformation in business ecosystems. Moreover, we provided 23 configurations for the six properties. Second, managers obtained insights about co-evolution novelties in business ecosystems with respect to digital transformations. For example, co-evolution in business ecosystems can be driven by enabling digital technologies, which are the core of digital platforms.

Based on our discussions of the findings, we suggest five avenues for future research. First, as we annotated for the existing literature on co-evolution processes, we were surprised by the limited occurrence of platforms, particularly digital platforms lying at the center of value creation. Thus, we suggest the use of co-evolution theory to examine platform ecosystems. Second, regarding technologies enabling co-evolution, we suggest the analysis of boundary resources, such as application programming interfaces (API) [Ea15, UY16]. Um and Yoo [UY16] understood APIs as the key role of managing the tension between control and generativity of a platform. We suggest that we should also study the effect of changing APIs over time on the business model of complementors or service offerings in platform ecosystems. Co-evolution may be also helpful for determining the effect of API changes on value capturing or value co-creation. Third, regarding multi-directional causality in platform ecosystems, there is a gap in how cooperation or competition can be leveraged. Thus, competition via different platform ecosystems (e.g., Android or iOS) should be examined. Fourth, the nonlinearity configurations of diffusion, hierarchy, network, or big bang could be used to design longitudinal studies for examining co-evolution. Further, we suggest that researchers seek to detect managerial co-evolution mechanisms driving positive feedback in platform ecosystems. Thus, scholars could shed light on co-evolutionary mechanisms for platform owners to enable the co-evolution of complementary partners. Mechanisms used to manage the evolution of platforms should also be evaluated.

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