Chapter 1
Exploring Radical Market Changes as Phase Transitions of Service Ecosystems: Insights from Complexity Science

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Abstract The multiple current transformations can determine complex radical market changes. Many market actors feel an increasing need to make sense of market dynamics, which bring opportunities but also threats. We leverage on the Service-Dominant logic and deepen its roots in complexity science to delineate radical market changes (i.e., phase transitions of service ecosystems). In particular, within complexity science literature, we found that phase transitions are approached in three diverse ways: shifts to a new complex order, shifts to a region of complexity where chaos and order achieve a balance, and shifts to escape chaos. We show that those three approaches can be integrated to give a full explanation of the dynamics of the service ecosystems. Then, we reconcile the approaches with the S-D logic narrative to delineate the complexity science insights into the phase transitions of service ecosystems. In doing so, we highlight some interesting concepts to further explore within S-D logic: institutional instability and service ecosystem viability

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near the edge of chaos, and institutionalization due to self-organized criticality. The implications connect the conceptual findings to the practice of market actors facing transformations.

Keywords Value co-creation · Service ecosystems · Complex adaptive systems · Digital transformation · Complexity science

Introduction

Markets are not stable backdrops to business but may be seen as complex adaptive systems (Holland 2014) able to produce novelty and surprises (Markose 2005; see also Giesler and Fischer 2017), especially when introducing or applying new technologies, such as blockchain and cryptocurrencies (Allen et al. 2022), generative AI (Fui-Hoon Nah et al. 2023), and others. Thus, markets can be conceived as made up of a variety of networked actors (suppliers, customers, third-party organizations, authorities, etc.) integrating resources among which technologies (Lusch and Vargo 2014) for co-creating value (Blaschke et al. 2019). In this view, the multiple current digital transformations (Vial 2019) do not only occur at the company level but may determine complex radical market changes with environmental, societal, and institutional implications (Kaartemo and Nyström 2021; Kraus et al. 2021), as in the case of the current transition towards renewable energy sources around the world (Sarno and Siano 2022). Thus, market actors feel an increasing need to make sense of market dynamics (Nenonen et al. 2014), especially the large-scale step changes, since change can bring opportunities (such as operational efficiency or increased market share) but also threats (as loss of competitiveness or market dissolution). Moreover, it should not be neglected that, although market changes are complex, they can be somehow triggered (Li 2020), facilitated, conditioned, or prevented and, in some cases, computed and forecasted, and in general, must also be understood if the "simple" adaptation is pursued (Kraus et al. 2021).

Service-dominant logic (S-D logic) (Vargo and Lusch 2004, 2008, 2016), acknowledged as a systems-based general theory of markets (Akaka et al. 2021), can contribute to understanding radical market changes by observing them through the lenses of the service ecosystem (Vargo and Lusch 2016). The concepts of phase transitions have recently enriched S-D logic to describe radical system changes (Polese et al. 2021) entangled with institutional change (Kijima et al. 2016; Polese et al. 2021; Pels 2020; Pels and Mele 2022). This means to make sense of radical market changes not just for the advantage of a focal market actor (Peters et al. 2020; Cantwell et al. 2010) but to observe the overall evolution of the system. In other words, we aim to leverage S-D logic and deepen its roots in complexity science (that deals with complex adaptive systems as markets are) to better delineate radical market changes (i.e., phase transitions of service ecosystems). In particular, synthesizing previous definitions and building on the insights from complexity science, we define phase transitions of service ecosystems as a *shift to a new service ecosystem order near the edge of chaos.*

Thus, we first introduce S-D logic and phase transitions of service ecosystems (Sect. 1.2). Then, we present and integrate diverse (Phillips and Ritala 2019) complexity science schools of thought and transition approaches (Sect. 1.3). This allows us to reconcile such diverse perspectives through S-D logic and delineate the insights of complexity science into service ecosystem phase transitions (Sect. 1.4). The presentation of the theoretical contributions (Sect. 1.5) and the future research questions (Sect. 1.6) follow. Finally, in Sect. 1.7, the implications connect the conceptual findings of the chapter to the practice of market actors facing digital transformations.

S-D Logic and Phase Transitions of Service Ecosystems

S-D logic is an acknowledged theoretical framework indigenous to the marketing field. Lusch and Vargo (2014: 24) define service ecosystems as a "relatively self-contained, self-adjusting system of resource-integrating actors connected by shared institutional arrangements and mutual value creation through service exchange." Service ecosystems have become foundational to marketing studies since they allow underscoring the systemic nature of value co-creation, which is a multi-actors process enabled (and constrained) by institutional arrangements, such as shared rules, norms, symbols, languages, beliefs, etc. (Vargo and Lusch 2016). Moreover, adopting a complex adaptive systemic approach allows analyzing market dynamics, co-evolution, and co-viability with other nested and overlapping ecosystems. S-D logic adopts a multi-level perspective, which considers service ecosystems multi-layered and that different viewpoints can be used to analyze ongoing phenomena (Vargo and Lusch 2016).

Within S-D logic, work on change (Kleinaltenkamp et al. 2018; Tuominen et al. 2020) and large-scale step changes, i.e., phase transitions (Polese et al. 2021), are mostly related to institutions and institutional arrangements. These studies are aligned with the extant studies that have looked at links between S-D logic and the role of institutions, institutional arrangements, and institutionalization (e.g., Pohlmann and Kaartemo 2017; Vargo and Lusch 2017; Brodie et al. 2019; Vargo et al. 2020). Near to our interest we find: (1) works associating the importance of agreed norms and standards to achieve new meanings (Peñaloza and Mish 2011); (2) studies linking innovation to the result of ongoing negotiations and recombination of overlapping and intersecting institutions (Akaka et al. 2021; Kaartemo et al. 2018) and institutional complexity (Siltaloppi et al. 2016); (3) research on institutional work seeking to understand how service ecosystems change (Nenonen et al. 2018; Lintula et al. 2020); and (4) articles on the emergence of institutions and service ecosystems adopting agent-based modeling (ABM) (Fujita et al. 2018).

Specifically, potential sources of institutional change are: external environmental disturbances to the service ecosystem as megatrends not aligned with current institutional arrangements creating tensions (Kleinaltenkamp et al. 2018); actors' resource integration bringing the emergence of new service ecosystem properties (Peters 2016; Polese et al. 2020; Vargo et al. 2023a, b). Accordingly, Polese et al. (2021) define the phase transition process of a service ecosystem as a large-scale step change that occurs when external environmental disturbances and internal actors' resource integration dislodge the ecosystem from a state of stability into de-institutionalization and re-institutionalization, ending with the achievement of a new stable state. Such a new state is characterized by new institutional arrangements and value as a new organizing principle providing order and organization to the actors' interactions in the service ecosystem. Polese et al. (2021) were mainly based on literature from physics and the theory of synergetics, thus mainly focused on one of the approaches to phase transitions available in the complexity science literature. Moreover, considering complexity science and the collective nature of the phenomena, size has been recognized as central to achieving the diffusion of change (i.e., increasing returns to scale) (Vargo et al. 2020).

In short, within the S-D logic narrative, service ecosystem and phase transitions have been described as linked to the institutional change literature. However**,** we agree with Pohlmanna and Kaartemo (2017) signaling that institutions have become crucial to the development of S-D logic but need further development, as well as Vargo and Lusch's (2017: 55) statement that the role of institutions and institutional arrangements, in the future, "is to become considerably more evident in S-D logic." In other words, within the literature on service ecosystems, a unified understanding and description of the mechanisms of how phase transitions come about and the role played by institutional change is still missing.

Integrating Complexity Science Approaches to Phase Transitions

Complexity science and general systems theory (von Bertalanffy 1972) seek to provide a general understanding of (complex) systems behavior. Insights from physics (Prigogine and Stengers 1984) and biology (Kauffman 1969) have been applied to diverse fields, such as economics (Arthur 2021) and social contexts (Mathews et al. 1999).

Among the diverse types of systems, we focus on literature related to complex and complex adaptive systems (CAS) because they are more appropriate to explain complex social phenomena such as phase transitions. The main features of *complex systems* are (for details, see Cillers 1998): (1) they aggregate heterogeneous components—actors and resources–that interact, giving rise to emergent properties of the whole (so that the properties of the whole cannot be predicted by nor reduced to the properties of the components); (2) they incorporate amplifying (positive) and

Table 1.1 Approaches to phase transitions in complexity science

	Schools dealing with complexity science			
	European school		American school	
Approaches to the concept of phase transition	Focus of the phase transition	System-environment processes	Intra-system processes	
	Definition of the phase transition	Shift to a new complex order out of chaos	Shifts to a region of complexity where chaos and order achieve balance	Shifts to a new complex order to escape chaos

Source Authors' elaboration

balancing (negative) feedback loops—chains of causality which are deviation amplifying and deviation counteracting—that foster or prevent systems change (Capra 1996); and (3) they have a non-linear behavior (so that small causes can have disproportionate effects—a famous example is the Lorentz's butterfly effect, according to which the small butterfly flapping its wings could, hypothetically, cause a typhoon, 1963). *Complex Adaptive Systems* add to complex systems adaptive capacities such as "self-generation, self-organization, decentralized control, memory, evolutionary and concurrent persistence and change (resilience), and anticipatory capacities" (Preiser et al. 2018 p. 5). In this chapter, we deepen these elements and show how they contribute to unfolding phase transitions in service ecosystems.

As mentioned, a phase transition is a significant system shift (Howe and Lewis 2005; Dooley 1997; Jantsch 1980). However, the justifications for such a shift seem profoundly heterogeneous and contradictory. To make order, we have first revised the main classifications of complexity science studies. In particular, Maguire et al. (2006) identified two Schools of thought/origin: the European one (e.g., Prigogine, Haken, etc.) with a focus on *system-environment processes* and dealing with "order out of chaos" system condition; and the North American one (e.g., Holling, Kauffman, and Arthur from the Santa Fe Institute) with a focus on *intra-system processes* and dealing with the "edge of chaos" system condition. Furthermore, focusing on the origin of the shift of the transition, a literature review allowed us to identify three basic approaches: (i) shifts to a new complex order; (ii) shifts to a region of complexity where chaos and order achieve a balance; and (iii) shifts to escape chaos. In the following subsections, we discuss each of the three approaches (see Table 1.1).

Phase Transitions as a New Complex Order Out of Chaos

The overall focus of the European School was on the interactions of complex systems–intended as "united wholes"–with their environment and the related tensions that would trigger a phase transition (Maguire et al. 2006).

This stream of research originated in Europe with studies on complex physical systems. It analyzed systems' ability to reconfigure into new ordered structures when undergoing energy forces brought to a certain critical level. In particular, Prigogine and Stengers (1984) describe how complex systems far from equilibrium can maintain their stability by producing energy, exchanging energy with the environment, and dissipating energy. Moreover, too much energy in a system that cannot be absorbed or dissipated by it can bring high instabilities and chaos. However, when a tipping/bifurcation point is achieved, new structures and forms of order may emerge spontaneously (Glansdorff and Prigogine 1971), thus causing both the old and the new systems to branch off into divergent paths. In these situations, the fundamental structures of those systems, called dissipative structures, evolve. In other words, order emerges "out of chaos" through self-organization (Prigogine and Stengers 1984). Thus, self-organization sustains the creation of emergent novel properties and modes of behavior that cannot be reduced to single elements (Fuchs 2003) and is due to the interactions of the components of the system in the process of development, learning, and evolution (Capra 1996), fostered and constrained by amplifying and balancing feedback loops (Lichtenstein and Plowman 2009; MacIntosh and MacLean 1999). Other studies in this area are related to the theory of synergetics, dealing with order, control parameters, and bifurcation points (Haken 1983) (bifurcation theory, instead, focuses on the discontinuities and instabilities driving them–for an overview, see Eidelson 1997).

The phase transition process according to this approach can be summarized as follows:

High instabilities–due to positive and negative feedback loops involving emergent properties–bring the system to a bifurcation point (disruption of equilibrium). Here, chaos is avoided thanks to self-organization, and a new order emerges.

Phase Transitions as a Region of Complexity Where Chaos and Order Achieve Balance

The American School studies on complexity science emphasize "intra-system processes resulting in emergent complexity and, in particular, the co-evolution of parts to a state […] beyond which order disappears, and disorder overwhelms the system" (Maguire et al. 2006, p. 169).

Based on the developments in computer science and drawing from life science, the American School focuses on heterogeneous agents and their co-evolution. In particular, agents are considered search for fitness (that is, agent's goodness) and thus able to adapt to the environment by changing their schemas (i.e., rules for interpretation and actor or, in other words, rules for fitness rewards). Changes at the micro-level can also depend on actions to adapt observations to existing schemas or changes to schemas due to adaptation to observations or combinations with other schemas. Furthermore, the heterogeneity and reactivity of agents (Rogers et al. 2005) can allow the diffusion of the new schemas and aggregations around them at the macro level (Dooley 1997). In this school, computational models are being developed to study interactions resulting in collective phenomena, trying to predict behaviors.

The American School pays particular attention to the notion of a system's "edge of chaos" state. The "edge of chaos" refers to the precarious balance of order and chaos (Holbrook 2003). Waldrop (1992: 12) clearly explains: "the edge of chaos is where new ideas and innovative genotypes are forever nibbling away at the edges of the status quo, and where even the most entrenched old guard will eventually be overthrown. … The edge of chaos is the constantly shifting battle zone between stagnation and anarchy, the one place where a complex system can be spontaneous, adaptive, and alive". At the edge of chaos, the disorder can create opportunities for learning and adaptability and preserves viability across changing conditions (Smith and Gemmill 1991); thus, this state is considered the only one where shifts can be viable. An interesting associated concept is "self-organized criticality." According to it, the "size and frequency of restructuring events … [of a phase transition] are related by an inverse power law" (Maguire et al. 2006, p. 167), which describes how propagation occurs at the edge of chaos. However, to avoid too much novelty that could overwhelm a system, some scholars believe that complex systems should be kept "near" and not "at" it (Anderson 1999). Similarly, many people experience their most productive moments near the temporal edge of the chaos of a deadline and learn how to make constructive use of an upcoming time limit (Pascale et al. 2001). In other words, the co-evolution toward the edge of chaos can bring the selective advantage of agents due to slight increases in fitness levels. At the same time, too big changes in fitness values (which can occur in chaotic environments) may not last long and result in lower fitness levels (Kauffman 1993).

The phase transition process of this approach can be summarized as follows:

High change (in the agent's schema) results from the interplay between local (micro level) and global (macro level) optimization of agents' fitness. Such change brings the system to the edge of chaos, where there is an increase in the fitness levels of the system, and chaos and order achieve balance.

Phase Transitions as a New Complex Order to Escape Chaos

Within the American School, some researchers considered chaos not as a state that needed to be balanced with order (as in the previous approach) but as a situation where the system might reach dissolution. Thus, they considered transition processes that allow complex adaptive systems to escape chaos and dissolution.

According to this approach, the system's dynamics are mathematically explained through power laws, showing that some metrics of the systems can increase more than proportionally. Here, the need for change depends on the co-evolution of parts composing the complex system that pushed the system towards chaos.

Moreover, the American School also developed social-ecological systems studies, introducing the concept of adaptation in complex systems (Gunderson and Holling

2002). Complex adaptive systems (CAS) draw on complexity science constructs to focus on human interactions and adaptation with/within nature (Colding and Barthel 2019). Though there is no unified CAS perspective (Preiser et al. 2018), generally, phase transitions have been termed "transformations" and defined as the "capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Walker et al. 2004, p. 1). In particular, Gunderson and Holling (2002) dealt with the adaptive pattern of ecosystems, explaining it as cyclical and made up of phases of increasing growth of the system that cannot be sustained and followed by renewal where some mutations, variations, or novelties previously occurred can be the source of a "new order" and result in a phase transition. Furthermore, they introduced hierarchical ontological levels within the ecosystem to explain change at some levels and cascade events to others.

Geoffrey West's study on scaling has contributed to understanding CAS behavior and related transitions (West 2017). 'Scaling' refers to how a system responds when its size changes, with a particular focus on cities. West observed that when a city's population grows, many of its socio-economic metrics (both the positive ones, as the GDP, and the negative ones, as crime) increase more than proportionally. West labeled this characteristic superlinear scaling and argues that "this kind of growth behavior is clearly unsustainable because it requires an unlimited, ever-increasing, and eventually infinite supply of energy and resources at some finite time in the future to maintain it. Left unchecked […], it triggers a transition to a phase that leads to stagnation and eventual collapse […] Major innovations can therefore be viewed as mechanisms for ensuring […] a transition from one phase of the system to another having very different characteristics […] circumnavigating the potentially disastrous discontinuity." In other words, paradigm-shifting innovations are presented as a way to "reset the clock before potential collapse occurs" and "ensure open-ended growth" (West 2017, p. 416).

The phase transition process of this approach can be summarized as:

The increasing growth of variables characterizing agents in the system due to power laws makes the system unsustainable, directed toward chaos and collapse. A phase transition may occur driven by mutations, variations or novelties, and influences among levels.

Integrating Complexity Science Approaches on Phase Transitions

We draw on definitions of phase transitions from physics to integrate the different approaches to phase transitions provided in the previous subsections (McKelvey 2001; Maguire et al. 2006). McKelvey (2001), drawing on Mainzer (1997), identified two critical points (intended as values of energy of specific control parameters) a complex system can experience and which can change complex systems' behavior. The first critical point (or first-order phase transition) signals a transition from one state of the system to another, where the import of a certain energy from the environment is needed for the transition to occur. An example in physics is the liquid–solid transition when water becomes ice under certain temperature and pressure conditions. If we consider water as the chaotic phase and ice as the ordered one, "the molecules are forced to make an either-or choice between order and chaos" (Waldrop 1992). The second critical point (or second-order phase transition) is characterized by a continuous exchange of energy, which could also be infinite. An example is the transition from paramagnetic to ferromagnetic states or, in other words, when the material becomes magnetic due to a field force and stays magnetic, also when the field force is taken away. These transitions "are much less abrupt, largely because the molecules in such a system do not have to make that either-or choice. They combine chaos and order." (Waldrop 1992). The two critical points demark different kinds of phase transitions and define the upper and lower bounds of a region of emergent complexity (McKelvey 2001). Thus, thanks to the distinction between the two types of phase transitions in physics, we can see that the complexity science approaches to phase transitions refer to diverse things. Indeed, while the European School identified the phase transition (with the emergence of a complex order) as the first critical point, the American School dealt with the phase transition (with self-organized criticality) as the second critical point.

Thus, we argue that a full explanation of the dynamics of complex systems requires understating both Schools' and their three approaches. We developed Fig. 1.1 to help visualize this integration. It shows a spiral that highlights a complex (adaptive) system evolution. This spiral operates within the region of emergent complexity delimitated by order and chaos. Within this space, the systems experience change from the environment (first-order phase transition) and within (second-order phase transition). The spiral shows a sequence of phase transitions, where a new order replaces a previous (unsustainable, according to the second approach) one that was becoming chaotic to escape chaos. In contrast, the balance between chaos and order is sometimes sought to foster creativity and change. We notice that the first approach might seem similar to the third one, but the change that the systems experience in the latter is not sharp nor definitive and depends on the co-evolution of parts instead of inter-system changes, which might be cases of "less complex" systems.

Having integrated the main approaches to phase transitions in complexity science, we move to delineate how these insights relate to and contribute to our understanding of transitions in service ecosystems, particularly the role of institutions and institutional arrangements in service ecosystems.

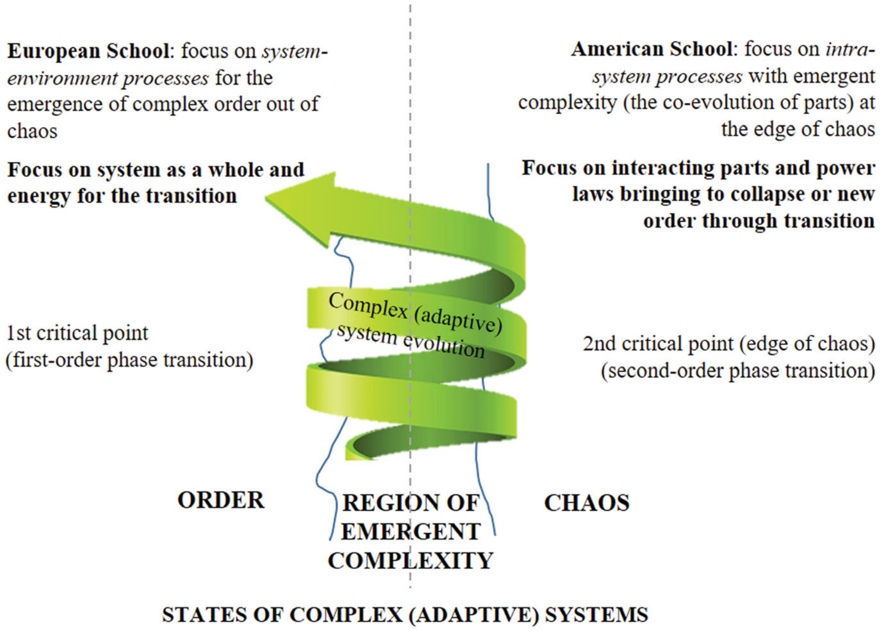

Fig. 1.1 Representation of complex systems states and phase transitions according to different schools and approaches. *Source* Authors' elaboration

Delineating Complexity Science Insights into Phase Transitions of Service Ecosystems

Having shown, in Sect. 1.2, the S-D logic state-of-the-art on phase transitions and institutional change and having integrated the three complexity science approaches to phase transitions of complex systems in Sect. 1.3, we now provide an S-D logic based reconciliation of the terms used in those approaches (see Table 1.2). Read with S-D logic lenses, phase transitions are affected by inter (otherwise named external disturbances) and intra-ecosystem processes (or internal actors' interactions) at macro, meso, and micro levels. As a result, S-D logic can leverage the two complexity science schools and accommodate them. Moreover, a service ecosystem may go through all the dynamics and evolution described in Fig. 1.1.

In Table 1.2, the first column shows the classical S-D logic narrative ("the organizing framework"), and the next columns represent the three complexity science insights ("the informing frameworks"), while the last column synthesizes the advancement of S-D logic due to incorporating the insights from complexity science. In the following subsections, we discuss and compare the narrative of the diverse approaches to phase transitions in complexity science with the S-D logic narrative moving over the rows of Table 1.2. Synthesizing previous definitions of phase transitions and building on the insights from complexity science, we define

Table 1.2 Reconciliation of terminology adopted in complexity science approaches to phase transitions and advancements of S-D logic

S-D logic narrative	Complexity science approaches to phase transitions (applications to social studies are mentioned in brackets)			S-D logic narrative incorporating phase transitions
	Shift to a new complex order out of chaos (emergence of new organizing principles)	Shifts to a region of complexity where chaos and order achieve balance	Shifts to a new complex order to escape chaos	Shift to a new service ecosystem order near the edge of chaos
Actors	Elements	Agents—characterized by heterogeneity and reactivity	Agents	Actors
Resources	Energy (information and other resources)	Resources	Resources	Resources
Emergence	Emergence	Emergence	Emergence (mutations, variations, and novelties)	Emergence
Value	(organizing principle)	Fitness (satisfaction in the system)	-	Value
Institutional arrangements	Dissipative structures (archetypes, mental models)	Rules for fitness rewards (schema; social norms)	Structures of the agents' networks underlying wealth creation	Institutional arrangements
Institutional complexity	Instability, high increase of energy (activities/events occurring outside the norm, lack of organizational coherence)	Lack of fitness of agents	Systems close to chaos, i.e., lack of resources to follow power laws	Institutional instability (edge of chaos)

(continued)

Table 1.2 (continued)

S-D logic narrative	Complexity science approaches to phase transitions (applications to social studies are mentioned in brackets)			S-D logic narrative incorporating phase transitions
	Shift to a new complex order out of chaos (emergence of new organizing principles)	Shifts to a region of complexity where chaos and order achieve balance	Shifts to a new complex order to escape chaos	Shift to a new service ecosystem order near the edge of chaos
Institutionalization -dealing with self-adaptation and self-adjustment	- Amplifying (also called reinforcing or positive) feedback loops amplify the reproduction/diffusion of emergent properties - Balancing (also called stabilizing or negative) feedback loops anchor the change by slowing the amplification of the diffusion of emergent properties - Self-organization	- Feedback between local and global optimization of agents' fitness - Feedbacks act at each level and among levels - Self-organization - Self-organized criticality	Power laws relating systems metrics among ecosystem levels	Institutionalization—dealing with self-adaptation, self-adjustment, and self-organized criticality
Service ecosystem viability	Far from equilibrium conditions, dynamic stability/equilibrium, order	Better fit at the edge of chaos	Avoidance of chaos	Service ecosystem viability, a system near the edge of chaos

Source Authors' elaboration

phase transitions of service ecosystems as "*a shift to a new service ecosystem order near to the edge of chaos*."

Actors, Resources, and Emergence The concepts of actors (in complexity science called elements, agents, or individuals), resources, and emergence are aligned with those described by the S-D logic (Vargo et al. 2023a, b); thus, they will not be discussed in detail.

Value (individual or collective) is a core organizing principle within service ecosystems (Meynhardt et al. 2016). This view is aligned with Polese et al. (2021) concept of the emergence of a new order (which draws from the concept of the order parameter of a phase transition). Also, as discussed in the second complexity science approach, the S-D logic concept of individual/intersubjective phenomenological determination is represented by the notion of local/global agent fitness, which, in organizational terms, means satisfaction in the system (Dooley 1997). Thus, the actor satisfaction in a system determines if it will try to maintain or change its status quo through changes in its practices and other institutional arrangements (for value co-creation) with other actors.

Institutional arrangements Structures—ruling and ruled by actors' interactions (Giddens 1984)—are recognizable in each of the three complexity sciences approaches and are compliant with the S-D logic narrative on institutional arrangements. Moreover, applications in organizational and management literature mentioned archetypes, schema (MacIntosh and MacLean 1999), mental models (Senge 1990), and social norms (Rogers 2003), directly referred to institutional theory (e.g., Giddens). When linked to the concept of fitness (discussed in the previous paragraph), institutional arrangements are considered rules for fitness rewards for actors (Dooley 1997). It is essential to note that institutional arrangements are not guarantees of optimal solutions but are often reasonably fitting to the surrounding situations (Fujita et al. 2019). Schema may adapt to a local optimum (Kauffman 1995) and become deeply ingrained and difficult to alter, thus representing maladaptation over the long run (Gell-Mann 1994). The "QWERTY" keyboard is an often-quoted example of such maladaptation (Arthur 1994).

Institutional complexity The emergence and institutionalization of new service ecosystem properties, such as new actors, resources, value, and institutional arrangements (Polese et al. 2021), can determine institutional complexity, i.e., a multiplicity of institutional arrangements with conflicting prescriptions for action that actors experience (Siltaloppi et al. 2016). Institutional complexity has diverse consequences in the service ecosystem. The deriving tensions between institutional arrangements can reduce the influence of prevailing institutions–and may drive to de-institutionalization; simultaneously, the new properties can also make new institutional "toolkits" available to actors, which may drive to re-institutionalization.

Within the European School, institutional complexity is captured by the word "instability," where it is described as initiated by activities or events occurring "outside the norm" in comparison to the context (Lichtenstein and Plowman 2009), or by new interpretative schemas or mental models. Such emergence is concurrent with increased instabilities and the loss of organizational coherence (MacIntosh and MacLean 1999).

The second approach describes the double face of institutional complexity, which is identified as a lack of fitness of agents, leading towards a change in the schema of agents (Dooley 1997). Along the same lines, the maladaptation mentioned above could be non-beneficial to the actors to the point of acknowledging its negative impact. As a result, when institutional arrangements lose their reasonable fit, it is often an indicator that there will be a change. The lack of fitness can lead the current pattern of the system towards the edge of chaos. As Waldrop (1992) wrote, "complex systems have somehow acquired the ability to bring order and chaos into a special kind of balance. This balance point–often called the edge of chaos–is where the components of a system never quite lock into place, and yet never quite dissolve into turbulence, either. The edge of chaos is where life has enough stability to sustain itself and enough creativity to deserve the name of life." Thus, although institutional complexity may seem detrimental to value co-creation because value loses meaning and may confuse actors, it is also a source of renewal. Here, the importance of heterogeneous interactions to bring adoption, mutation, or change is highlighted. Rogers et al. (2005) focused on two properties of CAS: variety/heterogeneity, already reported by Vargo et al. (2020), and reactivity. We highlight that both are related to the edge of chaos, a heterogeneous service ecosystem state where emergence is the likeliest. In such a state, the actors, in their variety, "can react more sensitively, increase their fitness, and change in a way that enhances chances for survival or forestalls threats of extinction." (Waldrop 1992, p. 6).

The consequent renewal is the objective of the third approach, where mutations, variations, and novelties can be the source of a "new order" in the growing phase of an ecosystem (Gunderson and Holling 2002). Here, the institutional complexity is due to the untenability of the current systems with its current institutional arrangements. In other words, the finite time singularity (according to superlinear scaling, it can be identified as a precise time in which the growth of the socio-economic parameters becomes infinite) described by West (2017) will happen, and the system must be renovated to survive.

We believe that the edge of chaos concept significantly contributes to understanding phase transitions within S-D logic as it captures the importance of institutional complexity and its role in making a service ecosystem viable. However, too much institutional complexity can also cause a system to collapse. Thus, we agree with the third approach rationale that the system must be near the edge of chaos but not at the edge of chaos. In other words, the system must constantly evolve, as in the spiral of Fig. 1.1, to stabilize/institutionalize for a while, taking advantage of the changes before changing again. This is why we argue that the expression 'institutional complexity,' though correct, does not capture the potential misalignments. As a result, we suggest adopting the label Institutional Instability (Edge of Chaos) in the last column of Table 1.2.

Institutionalization The abovementioned dynamics could result in the self-organization of the system. S-D logic has explained that service ecosystems are self-adaptive and self-adjusting systems responding to internal and external variations using positive and negative feedback loops (Vargo et al. 2023a, b). In other words, some ephemeral emerging properties can become institutionalized as proto-institutions (Kleinaltenkamp et al. 2018) or fully-fledged institutions. Though with a diverse focus, the interplay between feedback loops and self-organization is discussed in all three approaches to phase transitions. Here, we want to highlight the differences among the three approaches within complexity science and how each can enrich S-D logic's understanding of a phase transition.

According to the European approach, the feedback loops are systemic forces that can depend on the system-environment relationships and then connect service ecosystem components because they are embedded in institutional arrangements. Both amplifying (positive or reinforcing) feedback loops and balancing (negative or stabilizing) feedback loops act on the overall system. The former (amplifying) fosters the diffusion of emergent properties and results in deinstitutionalizing pressures (Oliver 1992; Greenwood and Hinings 1996) due to questioning taken-for-granted assumptions. Consequently, actors' self-organization is needed to emerge a new order. The latter (stabilizing) highlights the importance of anchoring and institutionalizing the change by slowing the non-linear processes led by the previous amplification of the diffusion of emergent properties (Lichtenstein and Plowman 2009).

Moreover, the work of MacIntosh and MacLean (1999) does not only emphasize that feedback loops foster change but also that there are institutional tensions with the feedback loops already in place, which determine the status quo. Furthermore, the de-institutionalizing/re-institutionalizing tensions are evident in external pressures, internal politics, and random couplings that combine as institutional arrangements to establish themselves in the face of resistance from defensive routines (Argyris 1990).

In the second approach, the institutionalization is driven by feedback between local changes and global optimization of agents' fitness. Thus, the second approach highlights the system's dynamics at different aggregation levels. Rogers et al. (2005) show that a global change can happen when local changes are significant (*critical mass inflection point,* the central point in the S-shaped diffusion curve), a concept captured by self-organized criticality. A widespread example to explain it is the sandpile: when sand is added on the top of a sandpile, the slope of the pile grows until a critical angle is reached, then such slope remains constant while the sand flows along it in the shape of avalanches of different size and duration, following power laws (Bak et al. 1991). Thus, the inflection point where the rate of new adopters changes (and increases significantly) is a phase transition, a situation in which, at the edge of chaos, self-organized criticality manifests through avalanches, which are explained as mutations and changes through which actors adapt (Rogers et al. 2005). At this point, the system processes new information and overcomes uncertainty. Furthermore, feedback can act within one level (for example, individuals influence others) or between levels, as feedback from the macro-level to individuals.

Finally, in the third approach, although there is attention to the co-evolution dynamics of actors that drive the change, the feedback loops, on average, are highlighted at the system level. The reason is that they are embedded in the power laws that relate systems metrics of all actors, such as the average growth of the system over time.

Again, the three approaches complement each other because they draw diverse causal forces (amplifying and balancing) connecting actors from the outside, within, and between different levels of aggregation and driving the institutionalization of emerging properties. Thus, the three approaches allow us to enrich Vargo et al.'s. (2023) generic discussion of the dynamics between emergence and institutionalization, which resented a causal interplay between parts and whole. Furthermore, the introduction of self-organized criticality alongside self-organization and self-adaptation enables the depiction of the systemic behavior that pushes a wide set of actors to change as 'avalanches of a sand-pile' when the institutionalization of new properties has become so pervasive to reduce uncertainty about the future and hesitations for actions. Close to the edge of chaos, such a tipping point is the state of the highest institutional instability.

Service ecosystem viability From the first approach, we have learned that the new order achieved through a transition in complex systems means that systems are not "static" but, as Capra (1996) recognized, it indicates the presence of order or organization while the systems need to dynamically change (dynamic stability) to stay viable.

The second approach highlights that, at the end of the phase transition, the lack of fitness, which was the engine of the transition, is overcome. Overall, there is an increase in the fitness level of the system. Each agent's change (to improve their fitness) could have changed the fitness landscape of the other agents in their network of relationships (Rogers et al. 2005). Such "global optimization enhances the CAS coherence as a system" (Dooley 1997: 87). In other words, the system coalesces since individuals have risen to the group threshold of fitness and adaptation (development into a fitter large-scale system). From this moment on, in innovation diffusion, there are enough adopters for further diffusion to become self-sustaining (Rogers 2003). However, collapse could occur if actors are inhibited in their ability to adapt interdependently (Rogers et al. 2005) and reciprocally influence fitness landscapes. The concept of fitness and the interplay between actors' and global fitness in the co-evolutions of actors above is one of the most interesting insights from the second approach to phase transitions. Vargo and Lusch (2017: 56) mentioned it referring to inclusive fitness as "likely to be particularly useful in informing S-D logic." We agree that it can "contribute to the discussion of value, especially as conceptualized in terms of change in the viability of a system." The value (fitness) an actor perceives depends on the actor's context (fitness landscape), which must be related to institutional arrangements, the actor's network, and resources. A fitness landscape can be graphically represented as a range of mountains the actor tries to climb (the tallest peak represents the site of the actor's potential maximum value). At the same time, they dynamically change due to actors' interactions. Furthermore, to reach their respective fitness peaks, co-evolving actors must adapt to one another (Eidelson 1997), giving birth to a service ecosystem. "As a result, their optima are no longer fixed and independent; the [actors] experience their shared environment as a landscape that constantly shifts and deform" (Eidelson 1997, p. 58). Although emergence, bounded rationality, and agency may cause different pathways that the optimal one to be followed, it is also true that the fitness landscape can offer a way to visualize actors' possible pathways and preferable interactions for value co-creation and increase the viability of the overall service ecosystem.

Finally, the edge of chaos is where the service ecosystem viability is the highest, but the untenability is the maximum. This is why, as already anticipated when dealing with institutional complexity, a service ecosystem should be kept near the edge of chaos. This is supported by the third approach, in which a transition is needed to avoid the edge of chaos and keep viability through change.

Theoretical Contribution

Central to marketing and management is theorizing on how actors—buyers, sellers, and other engaged stakeholders—can be involved in or adjust to changes in the system (intra-system processes) or to the system (system-environment processes). These changes can either be small and incremental or create a phase transition for the whole system. Incremental variations occur when the overarching institutional arrangements stay relatively intact. Here, research has highlighted ways for actors to adapt new insights into their existing solutions (incremental innovations) and become more agile (Teece et al. 2016) and flexible (Hatum and Pettigrew 2006), suggesting actors constantly sense changes in the market, seizing these insights into the organization and then transform their activities (Teece 2007). However, less guidance has been given on how actors should act during phase transitions.

The chapter extends recent conceptualizations of phase transition grounded in S-D logic and its service ecosystems perspective (Vargo et al. 2023a, b; Polese et al. 2021) by reconciling insights regarding phase transitions from three distinct complexity science perspectives. By integrating (MacInnis 2011) these three perspectives and delineating (MacInnis 2011) phase transitions in the S-D logic narrative, our findings try to strengthen the relationship between complexity science and S-D logic and emphasize the institutional dimension of the phase transition. In particular, at least three distinct contributions can be highlighted.

First, this study illuminates the distinct nature of three specific approaches to phase transitions in complexity science. By teasing out their inherent specificities, the European school is stated to focus on system-environment processes, whereas the American school, with unique features, focuses on intra-system processes. However, we go one step further and integrate these perspectives in Table 1.1 and Fig. 1.1. By focusing on the relationship with the environment, the European School links the emergence of complex order at the first critical point of a phase transition. Alternatively, the American School–stressing the intra-system process–relates phase transition to self-organized criticality at the second critical point. Both Table 1.1 and Fig. 1.1 allow us to visualize that the three approaches hold a dialectical and complementary relationship and that, combined, they allow a holistic understanding of the transition phenomenon.

Second, by reconciling the three complexity science approaches with the S-D logic narrative, we enrich S-D logic's understanding of phase transitions in service ecosystems (delineating contribution). Specifically, we highlight alignment with three core concepts of the S-D logic narrative (actors, resources, and emergence) and discuss the differences in the other concepts. The complexity science literature's main contributions are associated with the institutional-related insights, particularly through the introduction of the concepts of edge of chaos, which led to suggest substituting institutional instability to institutional complexity into the S-D logic narrative, and self-organized criticality, which allowed to propose that the S-D logic notions of self-organized criticality and self-adaptation can be complemented to it to explain institutionalization.

Finally, the reconciliation of the three complexity science approaches highlights the importance for service ecosystems researchers not to focus on finding ways for systems to be stable since stability, unfortunately, leads to the demise not only for individual actors but for the system itself. Instead, they allow drawing attention to the dynamic stability of service ecosystems near the edge of chaos, able to continuously renovate for viability without risking collapse.

Additionally, by discussing the extreme situation of phase transitions, this chapter enriches the set of concepts adopted in the S-D logic literature to discuss institutionalization and institutional arrangements, such as dissipative structures, rules for fitness rewards, power laws, local/global interplay, avoidance of chaos, feedback loops to diffuse change and stabilize the system. Finally, a phase transition of a service ecosystem that is not anchored by feedback loops regarding adjustments in institutional arrangements and the creation of new solutions for new problems might force the system beyond the edge of chaos into dissolution.

Future Research

Value co-creation, embedded in the service ecosystem, is a concept that emphasizes the importance of coordination and collaboration between various actors, creating a need for a shared understanding of how 'we do things' in practice (Taillard et al. 2016). However, turbulence may occur, for example, in response to intense social, economic, and political pressures or technological developments. A phase transition can occur, which requires the dismantling or restructuring current institutional arrangements and the emergence of new ones (de-institutionalization and re-institutionalization) (March and Olsen 1989; Peters 1999; Vargo, Wieland, and O'Brien 2023a, b). Future research could be oriented to further explore the processes of de- and re-institutionalization under the lenses of the three approaches to phase transitions shown in this study, as detailed in Table 1.3. The main elements are mentioned in the following.

The first approach involves studying how ecosystems can transition from chaos to a new order through self-organization and how institutional arrangements influence this process. For example, there is a need to investigate how the existence of formal

Table 1.3 Examples of future research questions deriving from the study

Complexity science approach to phase transition	Future research questions
Phase transitions as a new complex order out of chaos	Conditions under which service ecosystems move from a state of relative stability to a state of instability Dynamics of dissipative structures and how they emerge out of chaos through self-organization Role of feedback loops in amplifying and balancing emergent properties and promoting self-organization Factors that enable or inhibit the emergence of novel structures and behaviors Role of technology in fostering this type of transition
Phase transitions as a region of complexity where chaos and order achieve balance	Conditions under which the service ecosystem moves from a state of order to chaos or vice versa and how this affects its ability to adapt and learn Role of the "edge of chaos" in enabling complex adaptive behavior in various service ecosystems Role of feedback loops and information flows in promoting or inhibiting the emergence of complex adaptive behavior in various service ecosystems Dynamics of agent-based models, their co-evolution, and how this leads to emergent phenomena at the macro level Role of technology in fostering this type of transition
Phase transitions as a new complex order to escape chaos	Conditions under which institutional change occurs and how this affects the behavior of individuals and organizations within the ecosystem Role of institutions in enabling or constraining complex adaptive behavior in various service ecosystems Role of power laws, feedback loops, and information flows in promoting or inhibiting institutional change and innovation in different domains New theories or frameworks for understanding institutional change and innovation and designing interventions that promote these processes in different contexts Role of technology in fostering this type of transition

Source Authors' elaboration

and informal institutions can facilitate or impede the self-organizing process and how institutional change can affect the emergence of new structures and behaviors in the ecosystem. Additionally, it explores how feedback loops can influence the self-organizing process and how they can be amplified or balanced to facilitate the emergence and institutionalization of new structures.

The second approach covers how actors can achieve value co-creation while balancing order and chaos and how institutional arrangements influence this state. For example, researchers can investigate how institutional arrangements can facilitate or impede resource integration near the edge of chaos and how institutional change can affect the balance between order and chaos. Additionally, research can explore how achieving the edge of the chaos state can be influenced by the heterogeneity of actors and the diffusion of new rules for fitness rewards and feedback.

The third approach to phase transitions is related to a shift from chaos to a new order involving a continuous but large-scale step change process (as approach one, but less abrupt, with a focus on internal and environmental conditions and processes) needed to escape chaos and system dissolution. This approach particularly emphasizes the role of emergence as a driver of change; innovation is considered a key enabler with unpredictable outcomes. In service ecosystems, it can involve deepening the factors influencing institutional change, such as institutional entrepreneurs, power dynamics, and external shocks. Additionally, future research can explore the implications of institutional change for actors, such as changes in their identity, practices, and resource allocation. Besides, it can investigate the role of communication and sense-making in facilitating institutional change and how organizations can manage institutional change processes to minimize disruption and maximize opportunities for innovation.

The concepts of de- and re-institutionalization have important implications for further developing the service ecosystems perspective in S-D logic. Future research could explore the above areas to further the understanding of the role of institutions and institutional arrangements.

The (institutional) dynamics of the service ecosystem evolving through all of those phase transitions, as represented in Fig. 1.1, can be rewarding in identifying key drivers of viability and dissolution in diverse contexts.

Implications

Actors' characteristics to drive change Research has noticed the existence of *actors' abilities* to drive radical change actively. For instance, gaining a first-mover advantage (Lieberman and Montgomery 1988) or finding a blue ocean (Kim and Mauborgne 2004) can be prosperous for the actor and later for the system's viability. According to the European School of Complexity Science, it can be argued that the ability to regenerate, prosper, and improve under adverse situations, e.g., antifragility (Taleb 2012), can be achieved by embracing uncertainty. That is, amplifying feedback loops that are fostered by encouraging novelty (Lichtenstein and Plowman

2009). In comparison with minor system adjustments, in which actors could try to sustain and leverage institutional arrangements to predict the future–while focusing on dynamic capabilities (Teece 2007)–during phase transitions, courses of action are not predictable (Wiltbank et al. 2006) as the past no longer resembles the present. In these specific situations, actors' creativity, opportunity-seeking, and improvisation (Sarasvathy 2001; Weick 1998) are more likely to enable value co-creation. It can relate to creating radically new types of offerings and routines or changing the 'rules of the game' for all engaged actors in the service ecosystem. Actors operating in electronic markets should be particularly aware of these topics because new technologies significantly transform actors' abilities. For example, the metaverse has been considered an enabler of "creativity-guided co-creation" (Schöbel and Leimeister 2023). Furthermore, attention should be paid to "innovators" or, as Nicolò Machiavelli proposed in his book "The Prince", "the introductors of new orders". Those actors have as enemies all the supporters of the "old order" and as weak defenders all the potential beneficiaries of the "new order." Machiavelli concluded that not only the innovators need the occasion to propose something new, but also the virtue of seizing the opportunity and, finally, the resources to diffuse it.

Actors' resources are fundamental for a phase transition since resource integration for value co-creation can trigger the emergence of new systems properties (Peters 2016), which may trigger feedback loops (Vargo et al. 2023a, b), driving the transition. In the third approach to phase transitions, this is apparent thanks to the concept of self-organized criticality. Indeed, although power laws and feedback loops will foster the change, the initial differences among engaged actors are crucial to initiating a transition. Some actors have more resources to address the unbalance in the system by working towards a more coherent institutional arrangement than actors with fewer resources. In a system where all actors lack resources or are commonly unwilling to partake in harmonizing the institutional arrangements, the whole system may keep itself near the edge of chaos. This hints towards the critical importance of engaged and powerful actors in a system, especially according to the last approach. On the other hand, considering the first approach to phase transition, resources are needed to allow for the emergence of a new dissipative structure and to achieve a new equilibrium. For example, to explore and exploit the potential of Generative AI and transform markets, technical models (both general purpose and customized ones) must be integrated into service ecosystems (Banh and Strobel 2023), considering their specific characteristics regarding institutional arrangements and actors. In other words, only a context-aware Generative AI can be a powerful resource to support actors in their decisions.

Emergence (of new solutions) Then, *emergence* in search for mutations, variations, novelties, and creation of new solutions is fundamental for phase transitions. Indeed, as the service ecosystem goes from one phase to another, such as from the Iron Age to the Middle Ages, it creates the need for numerous innovations to solve problems that did not even exist in the previous (st)age. Stated differently, without radically new inventions to anchor the phase transition, the system might instead cross the edge of chaos and become chaotic. According to the American School, these multiple adjustments will most likely create numerous heterogeneous interactions in the system, some of which will become the source of a "new order" or bring the systems to further institutional complexity and collapse at the edge of chaos. The heterogeneity of actors, for example, has been one of the strategies identified for designing digital services for smart cities (Oschinsky et al. 2022). Most of the time, the emergence of new technological solutions "punctuates" existing market equilibria (Clemons in Alt 2022, leveraging the punctuated equilibria theory of Eldredge and Gould (1972) in evolutionary biology) and can be both beneficial and dangerous for market actors. However, as Clemons suggested, if you compare extreme cases that may happen in the future, you will not be precise enough to identify the new stable state of the service ecosystem. However, you may be accurate enough to drive your change while navigating the transition.

Institutionalization Later, for a phase transition, it is crucial to give rise to emergent properties and institutionalize new properties, working around numerous new and old institutional arrangements and resources to provide new solutions to new problems based on/thanks to feedback loops from the system. Indeed, these feedback loops enable the new properties either to be built on previous instantiation of institutional arrangements, as electric cars resemble gasoline cars down to specifics such as where to fill in the gas/electricity, or radical new inventions, as in the utilization of technologies the world did not even know about beforehand (e.g., Gen AI revolution). Drawing linkages between innovation and phase transition from a complexity science perspective, it can be stated that a phase transition for Rogers et al. (2005) occurs in the middle of the S-shaped curve of innovation, while the phase transition for West (2017) occurs between two paradigm-shift innovations or in other words before a finite time singularity is overcome thanks to the diffusion of one or more large scale step-change innovations. This can also bring to consideration that, if predictable, timing in the introduction of a new solution in an (electronic) market is fundamental: it should be postponed as late as possible to exploit current solutions but as soon as possible to make the critical mass inflection point occurring before the finite time singularity takes place.

A common point among the approaches is that the process of institutionalization contains *feedback loops*. Since homogeneous actors are more likely to interact, homogeneity can foster feedback loops to both diffuse change and balance it. Thus, homogeneity should be researched to allow institutionalization when a new solution has already been identified. For example, although the disruptive potential of quantum computing has been identified, with its "emerging new organizing logic and structure" (p. 2532), lack of actors' knowledge, budget for infrastructures, and shortage of experts can inhibit its institutionalization (Rietsche et al. 2022).

Finally, in dealing with the de/re-institutionalization needed for phase transitions, the dismantling of current institutional arrangements (de-institutionalization) is needed for a new set of coordinating activities across multiple actors, building new relationships with actors, and navigating cultural, normative, and even legal barriers. Re-institutionalization can take various forms, such as creating new regulatory frameworks, emergence of new professional bodies, establishing new forms of governance, or reorganizing new technological solutions. It creates opportunities for actors to engage in new and innovative ways and to develop more personalized and flexible institutions that meet the needs of the ecosystem's actors. This is the case of the current transformation of healthcare systems, boosted by the Covid-19 pandemic and digital technology advancements, that have de-institutionalized many practices and institutionalized others. However, the process has not brought the healthcare service ecosystem to new stability, and studies are trying to support researchers in capturing the current status of institutionalization of solutions and trying to forecast the future (Ostern et al. 2021).

Institutional work near the edge of chaos According to the American School concept of balance near the edge of chaos, a strategy for driving the service ecosystem towards a phase transition could consider the need to instill a change in institutional arrangements to promote a lack of satisfaction and understanding for agents and thus motivate them to enact change (Dooley 1997), while strengthening other institutional arrangements in place to loose not too much stability that could bring to collapse during the change. This type of institutional work (Koskela-Huotari et al. 2016) refers to "the purposive action of individuals and organizations aimed at creating, maintaining and disrupting institutions" (Lawrence and Suddaby 2006, p. 215). It is challenging in phase transitions according to which shifts are radical. Indeed, these disruptive activities most often occur within existing institutional arrangements (as actors cannot 'step outside' when trying to make a change). Furthermore, institutional work needs legitimacy in the service ecosystem for disruption (Thomas and Ritala 2022) to occur. As an ecosystem contains numerous actors guided by shared institutional arrangements, the legitimacy of the new and disrupted institutional arrangements is gained through a collective acceptance and institutionalization of these new institutions. This is often not straightforward and may imply contestations and conflicts (Gulati et al. 2012). For example, to develop standards for technologies and work practices in digital platform ecosystems, Costabile et al. (2022) suggested to: (i) developing new standards with the diffusion process in mind, so that the new solution itself can be considered beneficial for most of the target actors and likely adopted by them; (ii) engaging key actors in the process to enhance the possibilities of adoption and diffusion; (iii) leveraging extant standards and knowledge to keep at least in part the previous stability and build on it, trying to balance eventual drifts at the edge of chaos.

Thinking about the concept of self-organized criticality, for example, institutional work for driving a transition could be directed towards not waiting for the accurate development of a market strategy or the full understanding of other market actors' strategies before starting investments in a new technology. Indeed, the aggregation around a new technology could be already enough to acquire the critical mass to make the sandpile "flowing". A new avalanche of actors, then, will easily follow aggregating around the technology with a small uncertainty, and this amplifying feedback will bring new practices that, in turn, will provide the data to develop strategies and tactics around the technology.

Service ecosystem viability It also needs to be stated that phase transitions are central to the viability of a service ecosystem as the lack of change, according to complexity science, leads to stagnation and the system's death over time. However, a phase transition that lacks anchoring in new regulating institutional arrangements will drive the system to the edge of chaos. This is because a phase transition creates dynamic stability, forcing the actors to gain a better fit by avoiding the edge of chaos (as the three approaches suggest, respectively). Reconciled from an S-D logic perspective, indeed, the three approaches show that the viability of a service ecosystem is not related to a system in total harmony. Instead, viability can be related to crossing the edge of the complete order (first approach), moving into an area of complexity where order and chaos are balanced (second approach) by targeting institutional complexity, and trying to stay near the edge of chaos to renovate continuously, taking into account that institutional instability could also result in systems dissolution (third approach). Another way to keep the system alive is to actively drive change by creating disharmony in the system, such as instigating actors' dissatisfaction. These traditionally deviant behaviors can be central for the survivor of the system according to the three complexity science approaches. It also points toward the importance for actors to understand and act upon the feedback loops in the system. A relevant question from this insight is how little chaos is too little and how much chaos is too much for the system to handle.

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