# ECOSYSTEM TYPES IN INFORMATION SYSTEMS



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*Research paper*

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## Abstract

*As of now, the academic community puts increasing attention on the ecosystem concept. Subsequently, a plethora of ecosystem conceptualizations emerges blurring the concept and making accurate utilization increasingly difficult. To address that issue, the study reports on an in-depth structured literature review following established, rigorous guidelines, with the goal in mind to structure and analyze the differing ecosystem conceptualizations and to produce a harmonized understanding of them. Based on the identified literature, we inductively derive mandatory and differentiating characteristics that are suitable to explain ecosystem configurations. Next, we use established clustering procedures to identify groups of ecosystems from the literature. From that, we propose five idealized types of ecosystems. The goal of the study is to provide the research community and practitioners with a conceptually sound understanding of different ecosystem types and, thus, giving them a tool to develop their own ecosystem approaches on them.*

*Keywords: Ecosystems, Typology, Ideal Types, Literature Review.*

# 1 Introduction

Sciences and society are currently witnessing a paradigm change that entails a fundamental shift from a mechanistic towards a systemic worldview (Capra and Luisi, 2014). This systemic worldview emphasizes the interdependence and interconnectedness of the phenomena under study, with a particular focus on contextual and relational factors (Koskela-Huotari et al., 2016). In this connection, companies from various industries have transformed their previously hierarchical, linear supply chains into flexible networks of strategic alliances with external stakeholders during the last few decades (Bitran et al., 2007). Furthermore, as a result of the increasingly disaggregated character of technology development and specialist knowledge, firms are moving their locus of innovation from their own, internal research and development (R&D) facilities towards outside their firm boundaries, thus enabling collaborative innovation and R&D (Ritala et al., 2013; Baldwin and Hippel, 2011). This trend in the direction of more interconnected and collaborative business processes is further enhanced by digitally enabled networks, which provide new opportunities for less predefined and more dispersed organizational processes (Pagani, 2013). In this context, the concept of ecosystems has gained traction among researchers, practitioners, and policymakers recently, since this approach allows to investigate the interdependencies and interactions between various actors (Ritala et al., 2013). Recent calls for papers of top information systems (IS) journals (e.g., see MIS Quarterly (2019), Electronic Markets (2019)), and conferences (e.g., ECIS, 2020; ICIS, 2020), also highlight the significance of ecosystems for the scientific community. Generally, from an economic perspective, ecosystems are perceived "as evolutionary self-organizing cross-industrial systems of independent economic actors that are connected by value-added chains and behave similarly to naturalistic systems" (Benedict, 2018, p. 453).

Multiple authors have highlighted the abundance of ecosystem conceptualizations existing in the literature. For example, Seppänen et al. (2017) find ecosystem concepts with varying prefixes, including platform, mobile, innovation, or business ecosystems, and Benedict (2018) identifies seven dominant ecosystem types discussed in IS research. These concepts, rather than being clearly delimitable, are characterized by conceptual blurring and overlap (Hyrynsalmi and Hyrynsalmi, 2019). Resulting from this definitional and conceptual ambiguity is the overutilization of the term *ecosystem* and the associated risk of the creation of just another "buzzword" (Fuller et al., 2019). More recent papers have introduced yet more concepts, for example, that of *data ecosystems* (Oliveira and Lóscio, 2018). Thus, scholars find it challenging to identify, distill, and investigate the specific ecosystem concepts which are relevant for their particular field of research (Tsujimoto et al., 2018).

Our paper addresses precisely this issue and develops a comprehensive theoretical synthesis of the respective concepts. Thus, we conduct an in-depth analysis of existing ecosystem approaches and create a sound conceptual basis for understanding and delimiting ecosystems. Firstly, we identify relevant literature and concepts through conducting a structured literature review, following the well-established and rigorous recommendations of Webster and Watson (2002) and Vom Brocke et al. (2009). Next, in order to tackle the problem of blurriness between ecosystem terminology and its utilization, we develop a typology of ecosystems based on the derivation of generic characteristics from the literature. The merit of this approach is the decoupling from detail and the focus on the larger picture, which, we argue, is required presently because of the aforementioned vast landscape of ecosystem conceptualizations and their utilization (Weber, 1949; Watkins, 1952). Hence, our research question is as follows:

**Research Question (RQ):** Which generic ecosystem types can be derived from the literature in order to generate a harmonized understanding of ecosystem conceptualizations?

In order to achieve the goal of demarcation and creation of differentiability between the ecosystem concepts, we draw from the notion of *ideal types,* which represent a unique combination of the generic characteristics (Doty and Glick, 1994). We chose to draw from ideal types since these represent a suitable conceptual framework to codify conceptual knowledge, which has been abstracted and generalized. With the help of clustering methods, we derive idealized ecosystem types, as these are a suitable tool to create differentiability of ecosystem concepts. Once we identify the major concepts and their interrelations, the need for a clear demarcation of the field becomes distinct. Building on our first contribution, we are subsequently investigating the characteristics of the different ecosystem types.

The paper is structured as follows. First, we provide conceptual and theoretical fundamentals in ecosystem theory, beginning with the origin of the concept in ecology. Subsequently, we investigate the change and adaption of the term in IS literature. Following, we outline our approach to building the literature corpus, which, in Section 4, is then used to derive general characteristics. Also, we detail our types, and discuss the typology in Section 5. Lastly, in Section 6, we discuss the significant contributions of our work, as well as limitations.

# 2 Ecosystems

## 2.1 Origin, Definition, and Utilization

There is widespread agreement that the initial concept of *ecosystems* in the field of *ecology* was coined by Tansley (1935, p. 299), who proposed the following definition: ”But the more fundamental conception is, as it seems to me, the whole *system*, including not only the organism-complex, but also the whole complex of physical factors in the widest sense” (Lindeman, 1942; Willis, 1997; Richter and Billings, 2015). Nevertheless, as with many other concepts, there is no incontrovertible definition (see Table 1 for exemplary, selected definitions), but rather a multitude of more or less varying definitional approaches (Blew, 1996). Tansley (1935) introduced the term *ecosystem* to replace the then-used terminology *“complex organism”* or *“biotic community.”* He argued that a system-based approach is more meaningful than strict limitations onto the organism-based view. Then, Tansley’s (1935) conceptualization of ecosystems built on the compositional understanding of *ecology* as proposed by Haeckel (1866) and systems in the physics sense (Tansley, 1935; Weigmann, 2007). In that regard, ecosystems define the logic of the coexistence of living and non-living things under their environmental habitat (Evans, 1956). In the advent and throughout most of the 20th century, the ecosystem concept was used predominantly in the context of ecology (Willis, 1997; Jacobides et al., 2018), which is *“the branch of biology that deals with the relations of organisms to one another and to their physical surroundings”* (Stevenson, 2010, p. 557). Thus, the notion explicates ecosystems as the understanding of organisms living together (**ecology**) in delimited borders inhabited by interrelated and interdependent parts and elements (**system**) (Kast and Rosenzweig, 1972).

| Definition | Reference |
|---|---|
| “But the more fundamental conception is, as it seems to me, the whole *system* (in the sense of physics), including not only the organism-complex, but also the whole complex of physical factors in the widest sense.” | (Tansley, 1935, p. 299) |
| “The *ecosystem* may be formally defined as the system composed of physical-chemical-biological processes active within a space-time unit of any magnitude, i.e., the biotic community *plus* its abiotic environment.” | (Lindeman, 1942, p. 400) |
| “A biological community of interacting organisms and their physical environment.” | (Stevenson, 2010, p. 557) |

*Table 1. Selected biological definitions of the ecosystem concept throughout history.*

Since then, we can find multiple transfers of the ecological ecosystem concept onto additional domains, thus attracting scientific attention from outside the field of biology and establishing the concept as a central object of discussion in IS and management research (Adner and Kapoor, 2010; Jacobides et al., 2018). Furthermore, many studies draw from the biology analogy to explain the meaning of ecosystems within different contexts (see, e.g., Nischak and Hanelt (2019) or Nischak et al. (2017)). Probably the most prominent ecosystem analogy, at least in IS literature, is the conceptualization of various businesses that together form value creation networks, termed *business ecosystems* by Moore (1993). Business ecosystems, at that time, introduced as a strategic management concept (Adner, 2017; Iansiti and Levien, 2004), adopt an ecological approach to explain the underlying logic of the dynamics in platform-based cooperative networks (Moore, 1993). Moore (1993) considers ecosystems to be inherently shaped by *coopetition*, in which actors in the ecosystem both engage in friendly (cooperative) and hostile (competitive) relationships simultaneously (Bengtsson and Kock, 2000; Nalebuff and Brandenburger, 1997).

Ecosystems can be described as “a set of actors with varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled” (Jacobides et al., 2018, p. 2255). The roots of business ecosystems trace back to the advent of the automotive industry at the beginning of the 20th century, with the automobile as the central platform for complementary goods and services (Moore, 2006). Other domains to which the concept of ecosystems has been transferred to are, among others, *platform ecosystems* (e.g., Huang et al., 2009; Tiwana et al., 2010), *innovation ecosystems* (e.g., Adner, 2006; Adner and Kapoor, 2010), or *software ecosystems* (e.g., Jansen et al., 2009; Plakidas et al., 2016).

## 2.2 Ecosystem Types

According to Bailey (1994, p. 4), classification is the “(…) general process of grouping entities by similarity”. Classifications can be divided dichotomously into two approaches, one focusing on the empirical derivation of *taxa* (**Taxonomies**) and one referring to conceptually derived *types* (**Typology**) (Lambert, 2006, 2015; Baden-Fuller and Morgan, 2010). Both terms are frequently used interchangeably, which results a conceptual blurring (Szopinski et al., 2019; Gregor, 2006; Nickerson et al., 2013). Lambert (2006) and Lambert (2015) provide a productive juxtaposition of both terms by summarizing characteristic features of both approaches, which positions the present work as a *typology* rather than a *taxonomy* since we strive to construct general types relying on deductively derived characteristics. This understanding mostly corresponds with finding *ideal types* (or *“Gedankenbild”* (Weber, 1949, p. 90)), which are appropriate as they enable to not only explain reality through models but, more so, are a tool to explain deviations from them (Doty et al., 1993; Blalock, 1969; McKinney, 1966). This perception also corresponds with the typology understanding of Doty and Glick (1994, p. 232), which is as follows: *”(…) typology, refers to conceptually derived interrelated sets of ideal types.”* Thus, a taxonomy might be more helpful when classifying real-world objects yet lacks in assisting the goal of the study outlined above, which aims to demarcate conceptual boundaries of ecosystem approaches and, naturally, requires idealized types to make distinction possible. To achieve this goal, the types need to be general by design, rather than specific, meaning, that the underlying characteristics derived from the literature require stark generalization and abstraction (McKinney, 1966).

| Source | Short description | *Types* |
|---|---|---|
| *Hyrynsalmi and Hyrynsalmi (2019)* | The study identifies 23 types of non-biological ecosystems based on a literature review (LR), for example, Business Ecosystems, Data Ecosystems, Innovation Ecosystems, and platform ecosystems. | 23 |
| *Faber et al. (2019)* | The study identifies 12 types of business ecosystems based on a LR. | 12 |
| *Seppänen et al. (2017)* | The study identifies 11 research communities based on a LR. | 11 |
| *Benedict (2018)* | The study identifies seven types of ecosystems based on a LR classified alongside two dimensions, firstly, the nature of the systems and, secondly, its platform focus. | 7 |
| *Knodel and Manikas (2015)* | The study identifies 4 types of software ecosystems based on a LR. | 4 |
| *Jacobides et al. (2018)* | The study identifies 3 major types of ecosystems based on a LR. | 3 |

*Table 2. A summary of selected studies analyzing ecosystem types.*

To date, there exist a plethora of ecosystem concepts, with some authors listing more than ten different types. Table 2 provides a summary of selected studies that identify different ecosystem concepts and the corresponding number of identified ecosystem types. In the following section, we will explicate selective ecosystem conceptualizations that we have identified as the most dominant ones for Information Systems research. The selection bases on the analysis of the keyword frequency within the Scopus Database, where we searched for "Ecosystems" in sources whose title contains "Information AND Systems". We added “Innovation Ecosystems” as a significant concept within management research (Jacobides et al., 2018), to additionally account for adjacent fields. We did not include “Digital Ecosystem(s)”, although it is the most frequent ecosystem keyword since the articles are subsumable under the other concepts (e.g., Karhu et al., 2009; Briscoe and Wilde, 2006). Instead, the Digital Ecosystem can refer to any digitized ecosystem (Razavi et al., 2010; Nachira, 2002). Based on the reasoning above, we consider *Business, Platform, Service, Innovation, and Software Ecosystems* as most important from an Information Systems research perspective.

**Business Ecosystems** were introduced by Moore (1993) and apply ecosystem thinking into business relationships. Contrary to the more fundamental definitions stemming from *ecology* (see Table 1), the business ecosystem concept highlights the notion of a range of various interdependent and co-evolving actors complementing, through cooperation and competition, each other's capabilities to satisfy customer needs (Teece, 2016; Basole et al., 2015). While the notion of ecological ecosystems indicates self-organization, business ecosystems may both be dynamic or steered through a pivotal actor, for example, a platform (Teece, 2016).

**Platform Ecosystems** are novel in IS research, which becomes apparent by the increasing amount of discussions and scientific interest in the field of digitally-enabled ecosystems, such as app stores. Through app stores, developers might offer their products and services in the form of applications provided to the platform through *boundary resources,* such as *application programming interfaces* (API), *software development kits* (SDK), or *integrated development environments* (IDE) (Ghazawneh and Mansour, 2015; Ghazawneh and Henfridsson, 2013). These *boundary resources* empower developers with the technological equipment to contribute to applications and, in vibrant ecosystems, provide a consistent stock of external innovations (Tiwana, 2015). More generally, the notion of external innovation and third-party contributions represents a core principle of platform ecosystems. Thus, the platform is the technological infrastructure consisting of various modules to enable external innovation, whereas the corresponding, evolving ecosystem consists of users, vendors, and so on (Huang et al., 2009; Qiu et al., 2017; Tiwana et al., 2010).

**Service Ecosystems** are composed of service providers, consumers, and composition developers that collaboratively create new services, thereby adding value to the service ecosystem (Barros and Dumas, 2006; Papazoglou and van den Heuvel, 2006; Huang et al., 2014). The system's service-oriented architecture enables the continuous integration of various resources and the exchange of services between the different interconnected actors (Benedict, 2018; Huang et al., 2014). Due to the ongoing change in the service offering and dynamic interactions between the system's stakeholders, the service ecosystem is continuously evolving (Huang et al., 2014).

**Innovation Ecosystems** draw upon the concept of business ecosystems introduced by Moore (1993). Similar to the business ecosystem concept, the innovation ecosystem approach is also based on the notion of interconnected network actors (Gomes et al., 2018). Various stakeholders, such as focal companies, suppliers, customers, policymakers, and additional innovators, share sets of knowledge and skills to jointly co-create innovative products and services (Iansiti and Levien, 2004; Gomes et al., 2018; Carayannis and Campbell, 2009). However, despite the analogies between the business ecosystem and innovation ecosystem concepts, several researchers point to the differences between both approaches, with the main difference being that innovation ecosystems are related to value creation. In contrast, business ecosystems primarily refer to value capturing processes (Gomes et al., 2018).

**Software Ecosystems** integrate combinations of interacting actors upon a shared technological platform that generates new software and services (Manikas and Hansen, 2013). While there exist several different definitions of software ecosystems (e.g., Messerschmitt and Szyperski, 2003; Lungu et al., 2010; Jansen et al., 2009), the majority of definitions consider a standard software, the interdependent relationships between ecosystem stakeholders as well as business-related aspects, such as user satisfaction or revenue models, to be integral parts of the software ecosystem concept (Jansen et al., 2009; Bosch, 2009; Bosch and Bosch-Sijtsema, 2010; Manikas and Hansen, 2013).

# 3 Literature Review

Even though the scientific disciplines differ in their perception of knowledge and the means of creating it, they share the commonality of leveraging existing research published by scholars (Boell and Cecez-Kecmanovic, 2014; Schryen et al., 2015), which often employs the famous metaphor by Newton (1675), that describes scientific progress as "standing on the shoulders of giants". Our literature review follows established guidelines within the IS community (Webster and Watson, 2002; Vom Brocke et al., 2009). While there is a wide variety of different literature review types, which differ in their respective orientation and purpose (cf. Cooper, 1988), our focus lies on the attributes that the individual authors assign to the ecosystem concepts. Our approach can be described as a mapping study (Paré et al., 2015), which we conduct to identify the characteristics of the individual concepts and determine generic types of ecosystems.

We first select databases that cover the essential ISR Journals and conference proceedings (Peffers and Ya, 2003; Ferratt et al., 2007) and filter for peer-reviewed articles (Levy and Ellis, 2006; Webster and Watson, 2002). As these databases meet the outline requirements, we choose the AISeL, ACM, and Scopus databases. To determine the most important ecosystem types and in addition to that, a scope for further investigation, we perform an initial search for "ecosystems" (following Vom Brocke et al., 2015) within ISR journals and conferences (see Section 2.2). Based on the findings from that first, preliminary analysis (Okoli and Schabram, 2010), we conduct a second search iteration concentrating on Business, Platform, Service, Innovation, and Software Ecosystems. Although there exist other concepts, such as entrepreneurial or IoT ecosystems (e.g., Seppänen et al., 2017; Hyrynsalmi and Hyrynsalmi, 2019), we identify those five ecosystem types to be the key concepts within IS research. Figure 1 depicts and quantifies the summarized search process. After we made an initial reduction within the databases themselves, for example, by excluding biological and psychological contributions, we manually screened the remaining publications. Based on the manual selection, we only considered articles that deal with our research objectives in a non-trivial and non-marginal way (Okoli and Schabram, 2010; Vom Brocke et al., 2015). Finally, we conduct a short citation analysis of our literature core and a forward search of the most cited articles to include promising contributions to our research. The adjustment is made to include journal versions of conference papers if available.

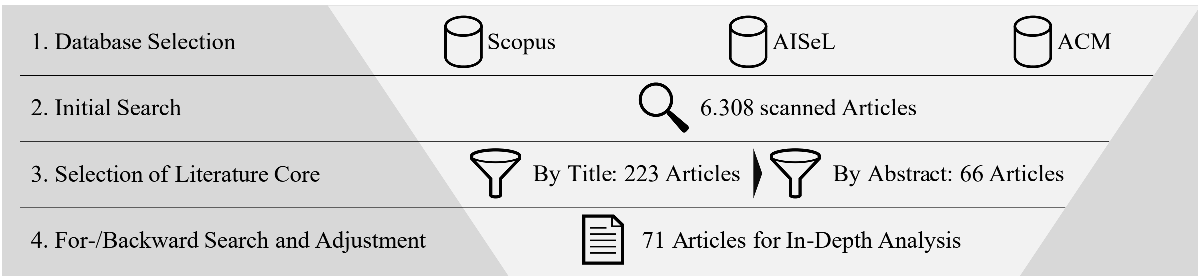


*Figure 1. Visualization of the literature search process.*

# 4 Ecosystem Types

## 4.1 Construction

The design of the ecosystem types bases on the literature review outlined in Section 3. We have identified 71 papers relevant to the present study and analyzed them to identify attributed ecosystem characteristics decoupled from their respective prefix (e.g., business ecosystems or innovation ecosystems). Table 3 shows the corpus of literature and the corresponding characteristics. Our analysis uses a dichotomous assessment logic, in that we differentiate between addressed and non-addressed characteristics. The former is visualized by full circles, the latter by hyphens. To improve the clarity and to structure our analysis, the discussion, and presentation, we grouped the characteristics utilizing a hybrid inductive-deductive thematic analysis (c.f. Fereday and Muir-Cochrane, 2006). While we mainly use inductive grouping, the process is influenced by the theories of social systems (Parsons, 1972), complex systems (Gao et al., 2012; Koskela-Huotari et al., 2016), and complex adaptive systems (Holland, 1992; Briscoe, 2010; Peltoniemi and Vuori, 2008). In the following, we discuss the groups of characteristics as derived from the literature study (see Table 3). Additionally, we present mandatory and differentiating characteristics (see Table 4) within the groups. A more detailed explanation of all identified characteristics can be found in the Appendix.

| Sources | Population | | | | Purpose | | | Relationship Structure | | | | | | | Sys. Config. | | | | Sys. Dynamic | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Distinct Roles | Specialization | Loose Coupling | Overlapping Industries | Innovation | Value Creation | NichesCreation | Interaction | Collective Intention | Resource Sharing | Symbiosis | Centralized Power | Balanced Power | Orchestration | Structuredness | Centricity | Coordinating Mech. | Stability | Adaptive Behaviour | Self-Organization | Lifecycle Pattern | Co-Evolution | Timing Relevance |
| Adner (2006) | - | ● | - | - | ● | ● | - | - | ● | ● | - | ● | - | ● | - | ● | - | - | - | - | - | ● | ● |
| Adner (2017) | ● | ● | - | ● | ● | ● | - | ● | ● | ● | - | - | - | - | ● | - | - | - | - | - | - | - | ● |
| Adner and Kapoor (2010) | ● | ● | - | - | ● | ● | - | ● | ● | ● | ● | ● | - | - | ● | - | - | - | - | - | - | - | - |
| Alves et al. (2017) | ● | - | ● | - | - | ● | - | ● | ● | - | - | - | ● | ● | - | ● | ● | - | ● | - | - | ● | - |
| Amorim et al. (2013) | ● | - | ● | - | ● | - | - | ● | ● | ● | ● | - | - | - | ● | ● | - | - | - | - | - | - | - |
| Barrett et al. (2015) | ● | ● | - | - | ● | ● | - | ● | - | ● | ● | - | - | - | - | - | ● | - | - | ● | - | - | - |
| Basole (2009) | ● | ● | - | ● | ● | ● | - | ● | ● | - | ● | - | - | ● | - | ● | - | - | - | - | - | ● | - |
| Basole and Karla (2011) | ● | ● | ● | ● | - | ● | - | ● | ● | - | ● | ● | - | - | - | - | - | - | ● | ● | - | ● | - |
| Basole et al. (2015) | ● | - | ● | - | - | - | - | - | - | - | ● | - | - | - | - | - | - | - | ● | - | - | ● | - |
| Basole et al. (2018) | ● | - | - | - | ● | - | - | - | ● | ● | ● | ● | - | ● | - | ● | - | - | - | - | - | ● | - |
| Bosch (2009) | ● | - | ● | - | ● | ● | - | ● | ● | ● | - | - | - | - | - | ● | - | - | - | - | - | ● | - |
| Briscoe (2010) | ● | - | ● | - | - | - | - | ● | - | - | - | ● | - | - | - | - | - | ● | ● | - | - | ● | - |
| Briscoe and Wilde (2006) | ● | - | - | - | ● | - | - | ● | ● | ● | - | ● | - | - | - | ● | ● | - | - | ● | - | - | - |
| Burden et al. (2019) | ● | ● | ● | - | - | ● | - | ● | - | ● | - | ● | - | - | - | ● | - | ● | - | - | - | - | - |
| Burkard et al. (2012) | ● | - | ● | - | ● | ● | - | ● | ● | - | - | - | - | ● | - | ● | - | - | - | - | - | ● | - |
| Ceccagnoli et al. (2012) | ● | - | - | - | ● | - | - | ● | - | ● | - | - | - | - | - | - | - | - | - | - | - | ● | - |
| Chae (2019) | ● | ● | - | - | - | ● | ● | - | ● | ● | - | - | - | - | - | ● | - | ● | - | - | - | - | - |
| den Hartigh et al. (2006) | ● | - | ● | - | ● | - | - | ● | - | - | ● | ● | - | ● | ● | - | - | ● | ● | - | - | ● | - |
| Dhanaraj and Parkhe (2006) | ● | - | - | - | - | ● | - | ● | ● | ● | ● | - | - | - | - | ● | ● | - | ● | - | ● | ● | - |
| Dhungana et al. (2010) | ● | ● | ● | - | ● | ● | - | - | ● | ● | - | ● | - | - | ● | ● | - | - | ● | - | - | ● | - |
| Gawer and Cusumano (2013) | ● | - | ● | - | ● | ● | - | ● | - | - | - | ● | - | - | - | - | - | - | ● | - | - | - | - |
| Goldbach et al. (2018) | ● | - | - | - | ● | ● | - | ● | - | ● | - | - | - | - | ● | ● | - | ● | - | - | - | ● | - |
| Handoyo et al. (2013) | ● | ● | ● | - | ● | - | - | ● | ● | ● | ● | ● | - | - | - | ● | - | - | - | - | - | - | - |
| Huang et al. (2009) | ● | ● | ● | - | ● | ● | - | ● | - | ● | ● | - | - | - | - | - | - | - | - | - | - | - | ● |
| Huhtamäki and Rubens (2016) | ● | ● | ● | ● | ● | ● | ● | ● | ● | - | ● | ● | ● | - | - | ● | - | ● | - | - | - | - | - |
| Iansiti and Levien (2004) | ● | ● | ● | - | ● | ● | - | ● | - | - | ● | - | - | - | - | ● | - | ● | - | - | - | ● | - |
| Isckia et al. (2018) | ● | ● | - | - | ● | ● | - | ● | - | - | - | ● | - | ● | - | ● | - | - | - | - | - | ● | - |
| Iyer et al. (2007) | ● | ● | - | ● | ● | ● | - | ● | ● | - | ● | ● | - | - | - | ● | ● | - | - | - | - | - | - |
| Jacobides et al. (2018) | ● | - | ● | - | - | - | - | ● | ● | ● | - | ● | - | ● | - | ● | ● | - | - | - | - | - | - |
| Jansen et al. (2009) | ● | - | - | - | ● | ● | - | - | - | - | - | - | - | - | ● | - | - | ● | - | ● | - | ● | - |
| Karhu et al. (2009) | ● | ● | - | - | - | ● | - | ● | - | - | - | - | - | - | - | ● | - | - | - | - | ● | - | - |
| Khadka et al. (2011) | ● | ● | - | - | - | - | - | ● | ● | ● | ● | - | - | - | - | ● | - | - | - | - | - | ● | - |
| Kim et al. (2008) | ● | ● | ● | - | ● | ● | - | ● | - | - | - | - | - | - | - | ● | - | - | - | - | ● | - | - |
| Kim et al. (2016) | ● | - | ● | ● | - | ● | - | ● | ● | - | ● | ● | - | - | - | - | - | - | - | - | - | - | - |
| Kim et al. (2017) | ● | ● | - | - | - | - | - | ● | - | - | - | - | - | ● | ● | ● | ● | - | ● | - | - | ● | - |
| Knodel and Manikas (2016) | ● | - | - | - | ● | ● | - | ● | - | - | - | - | - | ● | ● | - | ● | - | - | ● | - | ● | - |
| Koskela-Huotari et al. (2016) | ● | ● | ● | - | ● | - | - | - | ● | ● | - | ● | - | - | ● | ● | ● | - | - | - | - | - | - |
| Lettner et al. (2014) | ● | ● | ● | ● | ● | ● | - | ● | ● | - | ● | ● | - | - | - | ● | - | - | ● | - | ● | ● | - |
| Lihua et al. (2009) | ● | - | - | - | ● | ● | - | - | ● | ● | ● | - | - | - | ● | - | - | - | ● | ● | - | ● | - |
| Liu et al. (2010) | ● | ● | ● | - | - | - | - | ● | ● | ● | ● | - | - | - | - | - | - | - | ● | ● | - | ● | - |
| Lurgi and Estanyol (2010) | ● | - | ● | - | - | ● | - | ● | - | ● | - | - | - | - | ● | - | ● | - | ● | ● | - | ● | - |
| Lusch and Nambisan (2015) | ● | - | ● | - | - | - | - | - | ● | ● | - | - | - | - | ● | ● | ● | - | - | - | - | ● | - |
| Manikas (2016) | ● | ● | - | - | - | ● | - | ● | ● | ● | - | - | - | - | ● | - | ● | - | - | ● | - | - | - |
| Mele et al. (2018) | ● | ● | - | - | - | ● | - | - | ● | - | ● | - | - | - | - | - | - | - | - | - | - | - | - |
| Messerschmitt and Szyperski (2003) | ● | ● | ● | ● | ● | - | - | ● | ● | - | - | ● | - | - | ● | - | - | ● | ● | - | ● | ● | - |
| Moore (1993) | ● | ● | ● | - | ● | - | - | ● | ● | ● | - | - | - | - | ● | ● | ● | - | - | - | - | - | - |
| Nambisan (2013) | ● | - | - | - | - | ● | - | - | - | ● | - | - | - | - | ● | - | ● | - | ● | ● | - | ● | ● |
| Nenonen et al. (2018) | ● | ● | - | - | - | ● | - | ● | - | ● | ● | - | - | - | - | - | - | - | ● | - | - | ● | - |
| Ojuri et al. (2018) | ● | ● | ● | - | ● | ● | - | ● | ● | ● | ● | ● | - | ● | ● | ● | - | - | - | - | - | - | - |
| Parker et al. (2017) | ● | - | ● | - | ● | - | ● | ● | ● | - | ● | ● | - | - | - | - | - | ● | ● | - | - | ● | - |
| Peltoniemi (2006) | ● | - | ● | - | ● | ● | - | ● | ● | - | ● | - | - | - | ● | ● | ● | - | - | - | - | - | - |
| Plakidas et al. (2016) | ● | - | - | - | ● | - | - | - | ● | - | ● | - | - | - | - | ● | - | - | - | - | - | - | - |
| Qiu et al. (2017) | ● | ● | ● | - | - | - | - | - | - | - | ● | - | ● | - | - | - | - | - | - | ● | - | - | - |
| Razavi et al. (2010) | ● | ● | - | - | - | - | - | ● | - | - | - | - | - | - | - | ● | - | - | - | - | - | - | - |
| Riedl et al. (2009) | ● | - | - | - | ● | ● | - | - | ● | ● | - | - | - | ● | ● | - | ● | ● | - | - | ● | - | - |
| Ritala et al. (2013) | - | ● | - | - | ● | ● | - | ● | ● | - | ● | - | - | - | ● | - | - | - | ● | ● | ● | ● | - |
| Rong and Shi (2009) | ● | ● | ● | - | ● | ● | - | ● | ● | ● | - | - | - | - | ● | ● | - | - | - | - | - | ● | - |
| Rong et al. (2018) | ● | - | - | - | ● | ● | - | ● | - | ● | - | - | ● | - | - | - | - | - | - | - | - | ● | - |
| Saarikko (2016) | ● | ● | ● | - | ● | ● | ● | ● | ● | ● | ● | ● | - | ● | ● | ● | - | - | - | - | - | ● | - |
| Schettino et al. (2017) | ● | ● | - | ● | ● | ● | - | ● | ● | ● | - | - | - | - | ● | ● | ● | - | - | - | - | ● | - |
| Selander et al. (2010) | ● | ● | - | - | - | - | - | ● | - | - | ● | - | - | - | ● | ● | ● | ● | - | - | - | ● | - |
| Serebrenik and Mens (2015) | ● | ● | - | - | ● | ● | - | ● | ● | ● | - | - | - | - | - | ● | ● | - | - | - | - | - | - |
| Smith et al. (2016) | ● | - | - | - | ● | ● | - | ● | - | - | ● | ● | - | ● | - | ● | - | - | - | - | - | ● | - |
| Song et al. (2018) | ● | ● | ● | - | ● | ● | - | ● | ● | - | - | ● | - | - | ● | - | - | ● | - | - | - | - | - |
| Tan et al. (2009) | ● | - | - | - | - | ● | - | ● | ● | - | ● | - | - | - | ● | ● | - | - | - | - | ● | ● | - |
| Tian et al. (2008) | ● | - | ● | - | ● | - | - | ● | - | - | ● | ● | - | - | ● | ● | - | ● | ● | - | - | ● | - |
| Tiwana (2015) | ● | - | - | - | ● | - | - | ● | ● | - | ● | ● | - | - | - | - | - | - | - | - | - | - | - |
| Tiwana et al. (2010) | ● | - | ● | - | - | ● | ● | ● | - | ● | ● | ● | - | ● | - | - | ● | ● | - | - | - | - | - |
| van den Berk et al. (2010) | ● | ● | ● | - | ● | ● | - | ● | ● | ● | ● | - | - | - | - | - | ● | - | - | ● | - | ● | - |
| Vargo et al. (2015) | ● | ● | - | - | - | ● | - | ● | ● | ● | ● | ● | - | - | - | - | ● | ● | - | ● | - | ● | - |
| Wang et al. (2019) | - | ● | - | - | ● | ● | - | - | ● | ● | - | ● | - | ● | - | ● | - | - | - | - | - | ● | ● |

*Table 3. Overview of generic characteristics of ecosystems and corresponding sources.*

The **Population** is central to every type of system since the specific quantity of individuals (or actors) form a community (Parsons, 1972). The population's heterogeneity is essential and valid for all types of ecosystems (Gao et al., 2012), which is often expressed in *distinct roles* that actors can take (Barrett et al., 2015). *Specialization* (Adner and Kapoor, 2010) means the uniqueness of the actors' value propositions (Liu et al., 2010), and *loose coupling* refers to their openness (Rong et al., 2018). Both characteristics are essential to differentiate between the ecosystem types.

| Type | Explanation | Characteristics |
|---|---|---|
| *Mandatory* | Distinct across all clusters and not appropriate for differentiation. | Distinct Roles, Innovation, Value Creation, Interaction, Co-Evolution. |
| *Differentiating* | High variance between the clusters and used for distinction. | Specialization, Loose Coupling, Collective Intention, Resource Sharing, Symbiosis, Centralized Power, Orchestration, Structuredness, Centricity, Coordinating Mechanisms, Stability, Adaptive Behaviour, Self-Organizing. |
| *Others* | Neither characterizing for the clusters nor suitable for differentiation. | See Table 6 for the remaining characteristics |

*Table 4. Different kinds of characteristics. In-depth definitions are available in the appendix.*

The **Ecosystem Purpose** is essential as a decision-making maxim for participation and behavior in ecosystems (Smith and Stacey, 1997; Lurgi and Estanyol, 2010; Parsons, 1972). Parsons (1972) points out that a social system comprises a value system, which possibly entails social goals. For the case of the analyzed ecosystem types, we identify *innovation*, and generally *value creation* as fundamental goals for those communities (Adner, 2017; Adner and Kapoor, 2010). In platform ecosystems, the latter is often a result of the utilization of network effects (Song et al., 2018).

The **Relationship Structure** represents the social layer of the ecosystem and is the largest group of characteristics, which underpins its importance. Such as social systems emerge from the interactions between human actors and a respective "sense of 'belonging'" (Parsons, 1972, p. 254), the ecosystem's population forms from the actors' *interactions*, which represents the fundamental relationship type. Differentiating characteristics for the ecosystem types are the *collective intention*, representing a decentral decision making (Knodel and Manikas, 2016), *resource sharing,* and *symbiosis*, representing specific interactions (Iansiti and Levien, 2004; Vargo et al., 2015), *centralized power,* and *orchestration*, which both imply social centrality (Ritala et al., 2012; Dhanaraj and Parkhe, 2006).

**System Configuration** defines the static structure of an ecosystem, which mainly consists of tangible, physical characteristics (Briscoe, 2010). We identify four characteristics to differentiate the ecosystem types. First, *structuredness* refers to decentral interaction-enabling technologies (Amorim et al., 2013), second, a *centricity* that can relate, e.g., to products, innovations, platforms, or value propositions (Adner, 2017; Jansen et al., 2009). *Coordinating mechanisms*, as the third characteristic, refer to explicit or implicit rules that steer the coordination of the ecosystems (Tiwana et al., 2010; Vargo and Lusch, 2016). Fourth, the *stability* of an ecosystem refers to the robustness against external stimuli (den Hartigh et al., 2006).

**System Dynamics** entail characteristics referring to the systems behavior concerning environmental changes and variations over time. Some authors describe ecosystems as being, in general, dynamic (e.g., Basole et al., 2015), while others describe ecosystems as *complex adaptive systems* (e.g., Briscoe and Wilde, 2006; Liu et al., 2010). These are time-variant due to their differentiating *adaptive behavior* and *self-organization* of the actors and structures (Holland, 1992; Peltoniemi and Vuori, 2008; Briscoe, 2010). Additionally, *co-evolution* (Iansiti and Levien, 2004) is an essential characteristic of all types.

Given the structure of our documentation (see Section 3), we consider the individual papers and the respective ecosystem conceptualization as vectors. Thus, to find groups of conceptualizations that are more similar amongst each other than to other groups, we use cluster analysis. The cluster analysis was performed using the statistical programming language *R* and the package *"cluster"* (Maechler et al., 2018). In *R*, we performed *Agglomerative Hierarchical Clustering* (AHC) based on *Ward's Method*

(Ward, 1963), distance matrices generated using Gower (1971)'s coefficient, and comparison of clusters (e.g., for n = 4, 5, or 6). In the first iteration, the cluster analysis used all characteristics. Given our dichotomous classification of characteristics into optional and mandatory characteristics, we excluded the mandatory characteristics, as they were defined to be valid for all ecosystem concepts and thus do not provide meaningful grounds for differentiation. Therefore, we repeated the cluster analysis with the optional characteristics. We identified five clusters to be a valid solution by the visual analysis of the plotted dendrograms and the resulting clusters. In line with our understanding of *ideal types,* we then interpreted the clusters alongside their dominant characteristics, which also serve as the basis for naming them, and interpreted their idealized variation.

## 4.2 Generic Ecosystem Typology

Derived from the analysis above, we present five generic ecosystem types, as displayed in Table 5. In the following section, we describe the individual types, their dominant characteristics, and their interrelationships. Additionally, we showcase illustrative examples to make each type more tangible.

| # | Name | Dominant Characteristics | Description |
|---|---|---|---|
| *(1)* | *Sociocentric Ecosystems* | - Centralized Power<br>- Adaptive Behaviour<br>- Stability<br>- Loose Coupling | *Open communities that are organized around a social power, e.g., a keystone player, and evolve through adaptation to external stimuli.* |
| *(2)* | *Symbiotic Collective Ecosystems* | - Symbiotic Relationships<br>- Collective Intention<br>- Self-Organizing<br>- Specialization | *Closed communities focussing on symbiotic relationships to evolve their individual specializations.* |
| *(3)* | *Centrally Balanced Ecosystems* | - Centricity<br>- Collective Intention<br>- Loose Coupling<br>- Specialization | *Open communities sharing their resources and specialization on a central object, which is controlled by collective intentions.* |
| *(4)* | *Orchestrating Actor Ecosystems* | - Centricity<br>- Centralized Power<br>- Specialization<br>- Collective Intention | *Communities controlled by a central power and a central object used to orchestrate the individual specializations.* |
| *(5)* | *Structured Resource Sharing Ecosystems* | - Resource Sharing<br>- Structuredness<br>- Self-Organizing<br>- Coordinating Mechanism | *Closed community sharing its resources through technical structures to co-evolve, steered by coordination mechanisms.* |

*Table 5. Overview of the ecosystem types.*

**Sociocentric Ecosystems (1)** are centrally organized and focus on the social layer. Centrality is implicated by an actor whose advantage is an imbalance of power within the social system. The main emphasis is on the adaptive steering of the ecosystem in order to pursue stability and co-evolution. The system is open, and the actors enter the system for the purpose of creating symbiotic relationships and thus generate collective expectations towards the central actor. As an example, for the first type ***(see Figure 2: Type 1)***, we point to the case of ABB Canada in the mid-'90s (c.f. Moore, 1996). To overcome stagnating sales volumes, they take the innovative path to foster the regional economy instead of traditional cost-cutting. ABB formulated a strategy independent of specific technology that was dedicated to establishing a stable, long-term oriented partnership network, which is adaptive towards environmental changes. Their principal value proposition was to build an open network of partners around ABB and to relate their capabilities to the partners' activities for advancing their respective competitive advantages.

**Symbiotic Collective Ecosystems (2)** are characterized by an existing power equilibrium due to the absence of a central actor. The priority of this type is on the social level. At the heart of the decentralized decision-making lies the creation of symbiotic relationships, which, by using the unique abilities of the actors, are to enable co-evolution and value creation. Due to this decentralized system configuration, self-organization occurs. An example of *symbiotic collective ecosystems* ***(see Figure 2: Type 2)*** is the open innovation platform DEMOLA, which is presented by Huhtamäki et al. (2013). Its purpose is the solution of entrepreneurial problems by students who bring in the unique expertise of their discipline symbiotically. DEMOLA does not provide technical infrastructure, but brings together the user groups and organizes the offline innovation workshops.

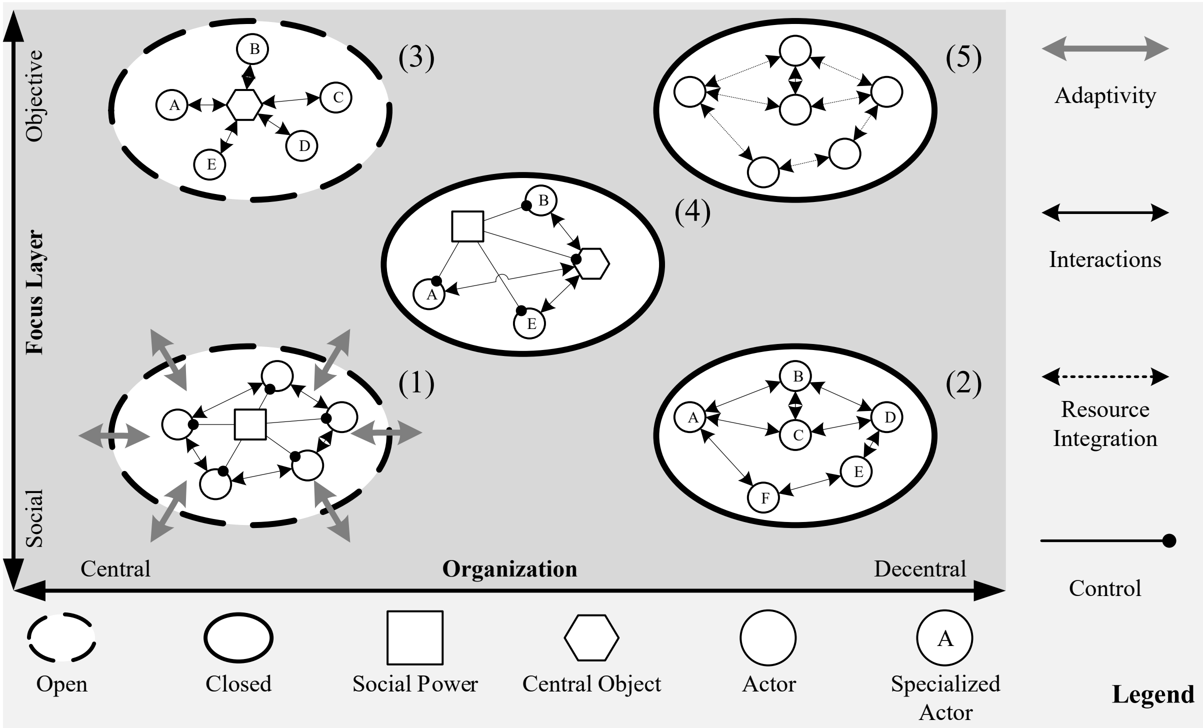


*Figure 2. Typology of ecosystems.*

**Centrally Balanced Ecosystems (3)** represent ecosystems that organize around a central object and have a balance of power. These ecosystems are controlled by coordinating mechanisms, which are integrated into the platforms or structures based on collective intention. The loosely coupled actors contribute their respective specialized capabilities and resources. Woodard (2016) describes the *Ag-Analytics platform*, which we propose as a representative example of *centrally balanced ecosystems* ***(see Figure 2: Type 3)***. The platform collects and aggregates data from a wide variety of sources so that researchers can use a single repository for research projects. The vision of the platform operators is to build an active community, which contributes to the further development of the platform.

**Orchestrating Actor Ecosystems (4)** are shown at the center of Figure 2 and are based on a sound balance between central organization and decentralized structures. A focus is placed both on the social and technical dimension, which is shown by the presence of a central object and an orchestrating actor. In such ecosystems, the orchestrator implements the collective will, thereby integrating the specialized capabilities of each actor in the direction of the common objectives. The SAP development partner ecosystem (Rickmann et al., 2014) is exemplary for the *orchestrating actor ecosystem* ***(see Figure 2: Type 4)***, as it demonstrates how a platform provider can foster a community by orchestrating the relationships. By restricting the access to the platform and guiding the development of its complementaries, SAP holds a central place in the ecosystem at all dimensions.

**Structured Resource Sharing Ecosystems (5)** are decentralized ecosystems with a focus on a shared objective. The integration of resources between actors is made possible by technical *structures* that contain coordinating mechanisms. The latter is based on collective intent and leads to self-organization of the ecosystem. An illustrative example of the *structured resource sharing ecosystem* ***(see Figure 2:***

***Type 5)*** is the API ecosystem as described by Evans and Basole (2016). Without central hubs or keystones, ecosystem actors can provide their resources amongst each other, which makes efficient resource integration possible. The technical infrastructure of digital technologies allows borderless interactions between participants of these self-organizing ecosystems.

# 5 Discussion of the Typology

Even though *de nomine*, our results consist of both a typology and five corresponding *ideal types,* we use Nickerson et al. (2013)'s five subjective conditions for a useful taxonomy as the existing knowledge base (as they argue that both terms are synonyms) to argumentatively discuss the quality of our typology (Hevner et al., 2004).

The criterion of ***conciseness*** refers to the typology being manageable, yet meaningful. Our typology proposes ecosystem types alongside two central dimensions, namely the *organization* and the *focus.* Additionally, we introduce visual, conceptual dimensions in the shape of icons (see Figure 2). Using these visual aids (e.g., canvases such as the Business Model Canvas) both assists in sharpening the comprehensibility, communicability, and delimitability of the conceptual content (Chandra Kruse and Nickerson, 2018). Thus, by summarizing all dimensions (including actors, interconnections between them, and systems borders), we reach five dimensions to which Nickerson et al. (2013) point to Miller (1956)'s "magical number seven" and give a span of plus or minus two dimensions for being adequately comprehensible and utilizable.

Next, the typology needs to be ***robust***, meaning that the dimensions sufficiently and meaningfully provide differentiation between the types. We argue that our dominant differentiating dimensions, such as the juxtaposition of central and decentral ecosystems, lie at the heart of the concept. Thus, it provides both the opportunity to find polar opposite ecosystem configurations (e.g., centralized ecosystems versus decentralized ecosystems), as well as to identify "shades of grey" in-between, as expressed by the visualization of the five types (see Figure 2).

The ***comprehensiveness*** refers to the ability of the typology to subsume all of the underlying objects or a relevant sub-sample. The typology builds on a structured literature review and identifies 71 papers relevant to our study (see Table 3). The types build on a clustering of the conceptualization of all 71 papers without the exclusion of any. Thus, all conceptualizations can be classified through these types, as each of them was used to derive it.

The typology needs to be ***extendible***, i.e., it must be possible to append additional dimensions easily. As we chose to explicate the types through a visualization based on multiple dimensional metrics, we believe that it should be relatively easy to introduce additional elements. One could, e.g., introduce another dimension through filling the objects with colors, which would be easily executable.

Lastly, the typology needs to be ***explanatory***, in that the chosen dimensions need to explain *enough* about an object to make it understandable. Similarly to the point of robustness, we argue that the types are explanatory as they comprise relevant dimensions spanning across various ecosystem conceptualizations and make them differentiable.

# 6 Contributions, Limitations, and Outlook

The paper provides two central contributions. Firstly, we develop generic characteristics of ecosystems and categorize them as either fundamental, i.e., mandatory for every ecosystem, or as optional characteristics. Second, we have identified generic types, thereby detaching the scientific discourse from the established concepts (e.g., business ecosystems, platform ecosystems, and innovation ecosystems) and concentrate on the essential characteristics of generic ecosystem types. Finally, our research allows existing concepts to be aligned with our typology so that that specific instances can be distinguished.

The **scientific contributions** are twofold. Firstly, we develop generic ecosystem characteristics, which may act as conceptual bedrocks for other researchers to build their concepts of ecosystems. Moreso, we differentiate dichotomously between mandatory and differentiating characteristics. Thus, researchers may find inspiration in identifying necessary elements of ecosystems they need to include if they were to design or conceptualize one. For example, we have already provided a visual representation of the types. Thus, it provides fertile soil for additional visual tools for ecosystem design, i.e., through innovating new design canvas, workshop concepts, or modeling tools. Lastly, sound definitions of terms are the basis for conducting successful research (Belnap, 1993). We argue that the proposed types resemble definitions of specific ecosystem configurations, which gives other researchers a structure while working with the concept.

The transformation of traditional supply chain networks to ecosystems is prevalent, also in practice. Thus, our work also produces **managerial contributions** as each type represents a possible strategic option for managers to either identify their current position in an ecosystem or strategize about their desired position. Hence, our work strengthens the clarity of the ecosystem concept, which thus provides managers a cleaner basis for aligning intra-organizational decisions with the ecosystem direction.

The typology and corresponding types that we propose are, naturally, subject to **limitations**. Firstly, we derive the types solely from the literature, which offers opportunities for incorporating practice-oriented findings, such as one would acquire in, e.g., case studies. Moreover, even though the typology builds on the quantitative analysis of data gathered through a literature review, the data collection itself is open to interpretation, which is why other researchers might find deviating characteristics. Given the inherent nature of idealized types, it is both an advantage as well as a limitation, as it demands to look at the bigger picture rather than each and all of the details. Thus, even though the types give ample conceptual assistance for conceptualizing and differentiating ecosystems, there is a need for tools that provide more in-depth details, e.g., in the form of an empirical taxonomy.

Derived from our findings, we identify three promising **research avenues**. First, to form a holistic theoretical grounding of the generic types, it would be promising to merge the existing knowledge of the ecosystem concepts via, e.g., a content analysis. Second, adding practice-oriented literature, such as case reports or strategic studies, to our approach would be an advancement, as we look forward to bridging the gap between our theoretical findings and business practice. Third, to address managerial issues, we propose to explicit the theoretical foundations of the alignment above of intra-organizational decisions within ecosystems.

## 7 Acknowledgement

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## Appendix

| Characteristic | Definition |
|---|---|
| **Mandatory Characteristics** | |
| *Distinct Roles* | Actors take on different roles to operate an ecosystem (Khadka et al., 2011). Roles can be, e.g., the platform providers (Saarikko, 2016), keystones, and niche players (Iansiti and Levien, 2004). |
| *Innovation* | Innovation is fundamental for gaining competitive advantages and can be achieved through the development of, e.g., technology (Adner and Kapoor, 2010), services (Lusch and Nambisan, 2015; Nambisan, 2013) or business models (Chesbrough, 2010). |
| *Value Creation* | This characteristic focusses on the (collective) creation of value, though, e.g., different types of complementary propositions (Jacobides et al., 2018). Value can be consist of, e.g., products, services, and content (Handoyo et al., 2013). Network effects are elementary for value creation in ecosystems (Katz and Shapiro, 1985; Parker et al., 2017). |
| *Interaction* | The relationship network bases on interactions between interdependent actors (Basole et al., 2015; Lusch and Nambisan, 2015). Those interactions can be specified, e.g., as transactions (Tian et al., 2008). |

| | |
|---|---|
| *Co-Evolution* | Co-Evolution can be described as an emergent process of continuous, interdependent advancement of two or more actors (Moore, 1993) and, e.g., their capabilities (Jacobides et al., 2018). Briscoe (2010) speaks of mutual "selection pressure" (p. 42). |
| **Differentiating Characteristics** | |
| *Specialization* | Refers to any contribution to an ecosystem (Knodel and Manikas, 2016), which is in most cases an individual offering (Adner, 2006) or value propositions (Vargo et al., 2015). |
| *Loose Coupling* | This refers to the openness of a system, as the actors have the option to leave the ecosystem and/or join another system (Lusch and Nambisan, 2015). From a systems theory point of view, this can be described as openness (Parker et al., 2017). |
| *Collective Intention* | This refers to an intrinsic motivation to participate and contribute in an ecosystem (Knodel and Manikas, 2016; Dhungana et al., 2010). It can become manifest, e.g., through coopetition (c.f., Nalebuff and Brandenburger, 1997) or collaboration (Hamel et al., 1989). |
| *Resource Sharing* | Specifies the base of interactions as the integration of resources, knowledge, and/or capabilities to create value collaboratively (Vargo et al., 2015; Basole, 2009). |
| *Symbiosis* | Symbiosis can be defined as a special form of interaction between, at least, two actors that gain mutual advantages from the relationship (Iansiti and Levien, 2004). |
| *Centralized Power* | Centralized power refers to a certain degree of centricity within the social subsystem, which can lead to "aristocratic patterns" (Basole et al., 2015, p. 24). |
| *Orchestration* | Refers to centralized decision making to create and capture value within a network (Dhanaraj and Parkhe, 2006) through "coordination by enabling" (Ritala et al., 2012, p. 325). |
| *Structuredness* | The technical base that allows the relationship network to interact (Amorim et al., 2013; Gawer and Cusumano, 2013) and therewith to exchange (in)tangible resources to reach its objectives (Briscoe and Wilde, 2006; Nambisan, 2013). Does not have to be platform-central, rather it can be decentralized (Lusch and Nambisan, 2015). |
| *Centricity* | Refers to a manifest central hub, which might be a (software) platform (Gawer and Cusumano, 2013; Plakidas et al., 2016), innovation (Burden et al., 2019), products (Jacobides et al., 2018), or more generally a value proposition (Adner, 2017). |
| *Coordinating Mechanism* | Refers to decision making and control in ecosystems. Encompasses, e.g., governance (Tiwana et al., 2010) or institutions (Vargo et al., 2015) that refer to, e.g., norms and rules, which are the most important aspects of actor configurations (Vargo and Lusch, 2016). |
| *Stability* | Important for establishing an coopetition equilibrium within ecosystems (Wang et al., 2019) and is closely related to the ecosystems health (Handoyo et al., 2013). |
| *Adaptive Behaviour* | Refers to the system's ability to react to external influences and environmental stimuli with internal changes (Holland, 1992; Lusch and Nambisan, 2015). This happens either through self-organization or central players and correlates with timing (Lusch, 2011). |
| *Self-Organization* | Implies decentralized decision making in a system without central power (Peltoniemi, 2006) to react on external stimuli by changing the system (Holland, 1992). |
| **Other Characteristics** | |
| *Overlapping Industries* | One of the fundamental premises of ecosystems is the transition from traditional perspectives (Moore, 1993) to the notion of economic communities "beyond the boundaries of a single industry" (Jacobides et al., 2018, p. 2257). |
| *Niche Creation* | Iansiti and Levien (2004) introduced this characteristic as elementary for measuring the ecosystem's diversity and its health. Niche players create value for themselves (van den Berk et al., 2010), influencing the systems evolution (Schettino et al., 2017), as their niches act as innovation clusters for the ecosystem (den Hartigh et al., 2006). |
| *Balanced Power* | This refers to a healthy balance between control of the orchestrator and autonomy of the other participants (Alves et al., 2017) to create sustainability (Razavi et al., 2010). |
| *Lifecycle Pattern* | Moore (1993) introduced the business ecosystem as an evolving, lifecycle-based economic system that implies the existence of development phases (Khadka et al., 2011). |
| *Timing relevance* | This characteristic refers to the dynamic capability (Nenonen et al., 2018) of the timing of decisions within an ecosystem, e.g., the launch of an innovation (Adner, 2006). |

*Table 6. Complete description of characteristics.*

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