

**Towards Ecosystems:
A Qualitative Analysis on the Early Stage of Inter-Firm Collaboration**

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The President:

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Executive Summary

The rules of our business game are changing ever faster. In particular, the rapid pace of digitization is dissolving the boundaries of previously rigid industries. It is therefore of fundamental importance for managers to broaden their perspective from the company level to a cross-industry view. In this way, firms have to compete with new competitors, but can also develop innovative value propositions and access new markets. For this reason, collaboration between firms is becoming increasingly important. Ecosystems are an innovative way of doing this. Ecosystems describe a group of firms that are aligned towards a common value proposition that is superior through the combination of the partners' core competencies. Interest in this phenomenon from science and practice has increased tremendously in recent years. Nevertheless, the research process is still in an initial stage and important questions remain unanswered. One central question, for instance, is how companies can successfully collaborate in ecosystems. At a deeper level of detail, this refers in particular to aspects of (i) ecosystem organizational structures, information processing and the role and perspectives of the two most important actors in ecosystems, (ii) orchestrators and (iii) complementors. These three research gaps are the motivation for this dissertation. In order to adequately address the individual questions, I conducted three multi-case studies. Firstly, my findings show three basic and distinct information processing structures of ecosystem actors. Secondly, the findings reveal the three types of single, double and multi-orchestrator ecosystems and elaborate on how firms allocate four key orchestrator tasks amongst ecosystem actors. Third, the results show three distinct types of complementors whose roles firms can perform dynamically. This dissertation thus not only addresses some of the key research questions of the ecosystem literature, but also provides important implications for managers. These implications help to design a targeted organizational structure and suitable orchestration model and to choose the right partners. In particular, they enable managers to anticipate their own role and the role of other partners in ecosystems based on their situation and goals. In other words: This thesis helps firms to successfully collaborate in ecosystems.

Kurzvorstellung

Die Spielregeln unserer Wirtschaft verändern sich immer schneller. Dabei führt vor allem die rasant fortschreitende Digitalisierung zu einer Entgrenzung bisher starrer Branchen. Für Manager ist es daher entscheidend, eine branchenübergreifende Perspektive einzunehmen. Unternehmen konkurrieren so mit neuen Wettbewerbern, können aber gleichzeitig auch innovative Wertversprechen entwickeln und neue Märkte erschliessen. Aus diesem Grund wird die Zusammenarbeit zwischen Unternehmen immer wichtiger. Eine innovative Form hierfür stellen Ökosysteme dar. Ökosysteme beschreiben eine Gruppe von Unternehmen, die auf ein gemeinsames und durch die Kombination der Kernkompetenzen der Partner überlegenes Wertversprechen ausgerichtet sind. Das Interesse aus Wissenschaft und Praxis an diesem Phänomen ist in den letzten Jahren sprunghaft angestiegen. Dennoch befindet sich die Forschung nach wie vor in einem Anfangsstadium und es bleiben wichtige Fragen offen. Diese beziehen sich beispielsweise auf Aspekte der (i) Organisationsstrukturen und des Informationsaustausches sowie der Rolle und Perspektive der beiden wichtigsten Akteure in Ökosystemen, (ii) Orchestratoren und (iii) Komplementoren. Für die Untersuchung dieser Forschungslücken wurden drei Multi-Case Studien durchgeführt. Die Forschungsergebnisse zeigen erstens drei grundsätzliche Strukturen des Informationsaustausches zwischen den Akteuren in Ökosystemen. Zweitens werden mit Einzel-, Doppel- und Multi-Orchestratoren-Ökosystemen drei Muster herausgearbeitet, wie die Akteure vier Kernaufgaben der Orchestration aufteilen können. Drittens zeigen die Ergebnisse drei zentrale Typen von Komplementoren. Diese Dissertation adressiert somit nicht nur einige der zentralen Forschungsfragen der Ökosystemliteratur, sondern liefert wichtige Implikationen für Manager. Diese helfen bei der gezielten Gestaltung der Organisationsstruktur, der Auswahl des Orchestrationsmodells sowie der Partner. Insbesondere ermöglichen sie Managern, auf Basis ihrer Situation und Ziele die eigene Rolle sowie die Rolle der anderen Partner in Ökosystemen zu antizipieren. In anderen Worten: Diese Dissertation hilft Unternehmen dabei, erfolgreich in Ökosystemen zu kollaborieren.

Table of Contents

List of Figures	VIII
List of Tables	IX
List of Abbreviations	X
1 Introduction	1
1.1 Motivation and Relevance.....	1
1.2 Overall Goal and Outline of this Thesis	3
2 Literature Review	6
2.1 State of the Art in Ecosystem Literature	6
2.2 Conceptual Difference to other forms of Organizational Collectives 12	
2.3 Research Gaps	16
2.3.1 Research Gaps on Information Processing	17
2.3.2 Research Gaps on Orchestrators	20
2.3.3 Research Gaps on Complementors	23
3 Methods	28
3.1 Data Sampling	29
3.2 Overall Description of Cases.....	31
3.3 Data Collection.....	44
3.4 Data Analysis	53
3.5 Caveat.....	57
4 Findings	59
4.1 Key Findings on Information Processing	59
4.1.1 Information Processing Structure of Pattern A	61
4.1.2 Information Processing Structure of Pattern B	68
4.1.3 Information Processing Structure of Pattern C	73
4.2 Key Findings on Orchestrators	80
4.2.1 Define Value Proposition	94
4.2.2 Implement Value Proposition	95

4.2.3	Coordinate Suppliers and Partners.....	97
4.2.4	Bring new Ideas	98
4.3	Key Findings on Complementors.....	100
4.3.1	Three Types of Complementors	100
4.3.1.1	Type A	101
4.3.1.2	Type B	111
4.3.1.3	Type C	118
4.3.2	Dynamics between the individual Types	123
4.3.3	Consequences of Dynamics for the other Actors.....	130
5	Discussion and Contribution to Literature	134
5.1	Contribution to Ecosystem Literature on Information Processing	134
5.2	Contribution to Ecosystem Literature on Orchestrators	137
5.3	Contribution to Ecosystem Literature on Complementors	140
6	Key Managerial Implications	143
7	Conclusion and Future Research Opportunities	149
	References.....	154
	Appendix.....	i

List of Figures

Figure 1: Ecosystem Research Foci of this Thesis	4
Figure 2: Citations of the Term "Ecosystem" per Year	7
Figure 3: Ecosystem Publications per Year	8
Figure 4: Overview of Ecosystem Sub-Streams	9
Figure 5: Coding Scheme for Study on Information Processing	55
Figure 6: Framework of the three Information Processing Structures	60
Figure 7: Framework of the three Orchestration Patterns	81
Figure 8: Framework of three Types of Complementors	130
Figure 9: Consolidated Managerial Framework of this Thesis	144

List of Tables

Table I: Key Conceptual Differences of Inter-Firm Collaboration.....	14
Table II: Summary of Research Gaps that inspired this Thesis.....	16
Table III: Overall Descriptions of the Cases	33
Table IV: Actor Classification of Cases for Complementor Study.....	42
Table V: Case and Data Overview of this Thesis	48
Table VI: Detailed Data Overview of Complementor Study.....	51
Table VII: Elements of Information Processing Structures	61
Table VIII: Proof for the Pattern A Cases in Study 1.....	63
Table IX: Proof for the Pattern B Cases in Study 1	70
Table X: Proof for the Pattern C Cases in Study 1.....	75
Table XI: Elements of Orchestration Patterns and Case Classification	82
Table XII: Proof for the Single-Orchestration Cases in Study 2	83
Table XIII: Proof for the Double-Orchestration Case in Study 2.....	88
Table XIV: Proof for the Multi-Orchestration Cases in Study 2	90
Table XV: Overview Complementor Types	101
Table XVI: Proof for the initial Type A Complementor in Study 3	107
Table XVII: Proof for the initial Type B Complementor in Study 3.....	115
Table XVIII: Proof for the initial Type C Complementor in Study 3	121
Table XIX: Key Contributions to Ecosystem Literature.....	151

List of Abbreviations

<i>3D</i>	<i>Three-Dimensional</i>
<i>AI</i>	<i>Artificial Intelligence</i>
<i>B2B</i>	<i>Business-to-Business</i>
<i>B2C</i>	<i>Business-to-Customer</i>
<i>cf.</i>	<i>confer (compare to)</i>
<i>C-level</i>	<i>Chief-level</i>
<i>COO</i>	<i>Chief Operating Officer</i>
<i>CSO</i>	<i>Chief Sales Officer</i>
<i>CTO</i>	<i>Chief Technology Officer</i>
<i>e.g.</i>	<i>Exempli gratia (for example)</i>
<i>et al.</i>	<i>et alii (and others)</i>
<i>FTE</i>	<i>Full Time Equivalent</i>
<i>i.e.</i>	<i>id est (that is)</i>
<i>OS</i>	<i>Operating System</i>
<i>R&D</i>	<i>Research & Development</i>
<i>SME</i>	<i>Small and Medium Enterprises</i>

1 Introduction

1.1 Motivation and Relevance

In recent years, companies have increasingly moved away from rigid industry silos. Due to digitalization, industry boundaries are increasingly dissolving and new, superior value propositions for customers are emerging (Atluri, Dietz, & Henke, 2017; Fuller, Jacobides, & Reeves, 2019). As a result, managers increasingly think beyond their traditional markets. Daimler does not just want to sell cars: it offers mobility (Reiter, Stonig, Dexheimer, & Lechner, 2018). Helvetia does not only want to sell insurance, but wants to offer its customers comprehensive solutions in the home sector (F. Huber, Miehé, & Lingens, 2019). Roche even regards collaborations between healthcare and technology companies as key driving forces for the future of healthcare (Pedrocchi, 2020). Across industries, firms realize that they cannot compete on this level with their own core competencies alone. Instead, it is crucial to use valuable know-how, ideas, practices and experience from other actors. Thus, the way that firms innovate has undergone a massive shift over time, from a traditional, firm-centric approach towards the current paradigm of opening up the innovation process (Chesbrough, 2006; Enkel, Gassmann, & Chesbrough, 2009; Frishammar, Richtnér, Brattström, Magnusson, & Björk, 2019; Masucci, Brusoni, & Cennamo, 2020). It is therefore no surprise that collaboration between firms has become increasingly relevant in recent years (Bogers, Sims, & West, 2019; Fuller et al., 2019; Müller, Buliga, & Voigt, 2020).

In this context, the ecosystem concept (Adner, 2017; Jacobides, Cennamo, & Gawer, 2018; also see Moore, 1993) experienced a tremendous boom in both industry practice and managerial research. This new and distinct organizational form is increasingly replacing the individual corporation as the sole unit of analysis (Baldwin, 2012). In short, ecosystems are a group of organizations that jointly create a value proposition for the customer that a single firm could not offer in isolation (Adner, 2017; Jacobides et al., 2018; Moore, 1993). Since

all of the organizations involved in the ecosystem are pursuing their individual agendas, the ecosystem actors need to be aligned towards this joint value proposition (Adner, 2017; Jacobides et al., 2018). Such alignment implies that ecosystems are not governed fully hierarchically, but rather through distributed decision-making processes (Jacobides et al., 2018). In addition to the presence of at least one orchestrating firm responsible for the involvement and coordination of the partners (Altman & Tushman, 2017; Iansiti & Levien, 2004b; Moore, 1996), there are several other actors, such as complementors and suppliers. In the context of ecosystems, complementors are particularly crucial. In contrast to suppliers, they provide non-generic modules that need to be aligned in order to create production and consumption related complementarity effects (Jacobides et al., 2018). These complementarity effects create a superior value proposition for the customer and are thus increasingly relevant for the success of innovation efforts (Bogers et al., 2019). For instance, in Apple's iOS, the fixed standards and interfaces enable other firms to specifically develop apps for the iOS ecosystem (complementarity of production) and more iOS compatible apps will increase the value of consuming Apple products (complementarity of consumption). This example shows that the nature of competition between firms is increasingly replaced by co-opetition (Jacobides et al., 2018; Moore, 1993, 1996). Managers of firms need to think from a higher level of aggregation and take an ecosystem perspective rather than a firm-centric perspective.

Indeed, firms have increasingly realized that ecosystems are highly relevant for their future business (Bogers et al., 2019; Peppard & Rylander, 2006). However, managers are unclear of how to successfully initiate and manage ecosystem collaborations, and academic research is only beginning to provide guidance (Autio & Thomas, 2020; Jacobides et al., 2018; Thomas & Autio, 2020). In fact, it remains an open question how firms can collaborate in ecosystems. First, research has not yet provided a satisfactory understanding of the overarching topic of organizational structures and information processing amongst ecosystem actors (R. Gulati, Puranam, & Tushman, 2012; Joseph & Gaba, 2020; Lawton, Rajwani, & Minto, 2018). Second, previous

studies have elaborated on the importance of orchestrators for the alignment of ecosystem actors, but the role of these firms is still a largely under-researched topic (Adner, 2017; Altman & Tushman, 2017; Iansiti & Levien, 2004b; Jacobides et al., 2018; Moore, 1996). Third, the role of complementors has remained vague (Adner, 2017; Jacobides et al., 2018). These considerations lead to the overarching research question of this thesis:

Q: How can firms successfully collaborate in ecosystems?

In a nutshell, ecosystems provide novel opportunities for firms, but how and in which roles firms can take advantage of these opportunities is still a black box. This is particularly relevant since firms face ecosystem specific challenges such as the interdependency of actors. Therefore, this thesis should shed light on these questions, contribute to ecosystem literature, and show firms pathways to successfully collaborating in ecosystems.

1.2 Overall Goal and Outline of this Thesis

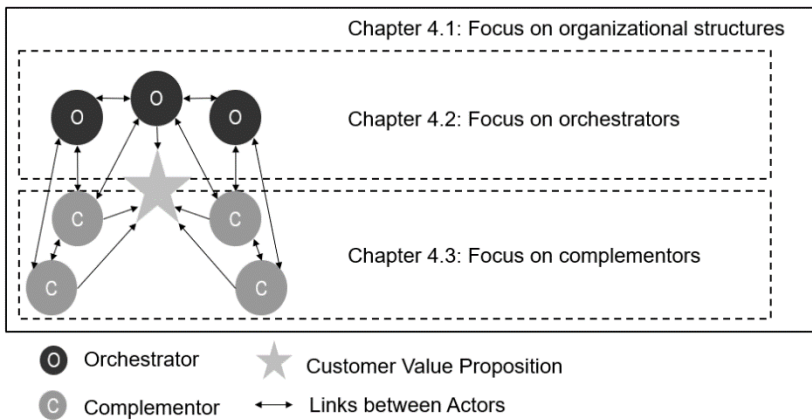
This thesis aims to address the research gaps briefly described in the previous chapter (for a detailed description, cf. chapter 2.3) and, thereby, contributes to research on ecosystems. The resulting overarching goal of this thesis is to provide insights into the overarching research question of how firms can successfully collaborate in ecosystems.

In order to address this research question systematically and comprehensively, this thesis uses a structured analysis approach. Chapter 2 provides a comprehensive overview of the literature on ecosystems. I describe the state of the art in ecosystem literature, the specific ecosystem characteristics, and a detailed analysis of the main gaps in the ecosystem literature that formed the basis of my research. Chapter 3 describes the methodology and provides detailed accounts of the sampling, collection and analysis of data.

My research covers three key sub-aspects of ecosystem collaboration, and each of these focuses on a distinct research question. Thus, three empirical studies, each with a distinct research focus, address these research questions. The

research focus of the first study lies on the general organizational structures and information processing amongst ecosystem actors. The other two studies proceed one level down and focus on the two most important sets of actors in ecosystems: orchestrators and complementors. To provide a clear structure, I have depicted the specific findings of each study in a separate chapter. All chapters are briefly described in the following in order to provide the logical structure. Figure 1 displays a sketch of this logic:

Figure 1: Ecosystem Research Foci of this Thesis



Chapter 4.1 of this thesis addresses the inter-organizational structures amongst ecosystem actors. Grounded by a multiple-case study, it develops three distinct types of information processing, thus providing a better understanding of how ecosystems are structured and governed. A framework summarizes the findings that allow managers a systematic approach and analysis of the ecosystem’s organizational structure. The following research question guides the analysis:

Q1: How can firms shape organizational structures amongst ecosystem partners in a way that information is processed accordingly?

Chapter 4.2 complements these results and focuses on orchestrators in ecosystems. Based on the insights regarding the organizational structures of the ecosystems, this chapter specifically addresses the roles of orchestrator firms. This chapter elaborates on single, double and multi-orchestrator ecosystems, and shows how firms allocate four key orchestrator tasks amongst ecosystem actors. Thus, it addresses the following research question:

Q2: How can firms allocate orchestrator tasks amongst ecosystem actors?

Chapter 4.3 covers the last piece of the ecosystem's mosaic and focuses on complementors in ecosystems. The study shows three distinct types of complementors that solve their contribution-reward trade-offs differently. These three types of complementors require distinct governance strategies for orchestrators. In this way, the study answers the following research question:

Q3: How can a complementor approach the contribution-reward trade-off between itself and the other actors in an ecosystem?

On the basis of these empirical findings, I show the theoretical contributions in the three key research areas in chapter 5. In an attempt to integrate all managerial implications in one comprehensive framework, I synthesize the most relevant findings for managerial practice in chapter 6. Lastly, this thesis provides a summarizing conclusion and encourages further research on the ecosystem topic in chapter 7.

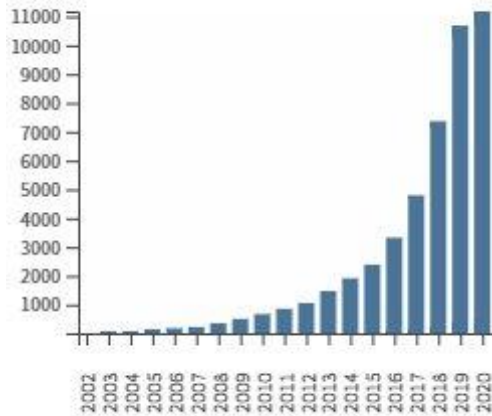
2 Literature Review

This chapter aims to provide a comprehensive overview of the literature on ecosystems. The first section describes the dynamic development of the literature stream as well as the theoretical foundations of the ecosystem concept. Based on these specific ecosystem characteristics, the second section shows the important conceptual differences to other forms of inter-firm collaboration and, thus, the novelty of the concept. Starting from this conceptual clarity, the third section provides a detailed analysis of the main gaps in the ecosystem literature, which formed the basis of my research.

2.1 State of the Art in Ecosystem Literature

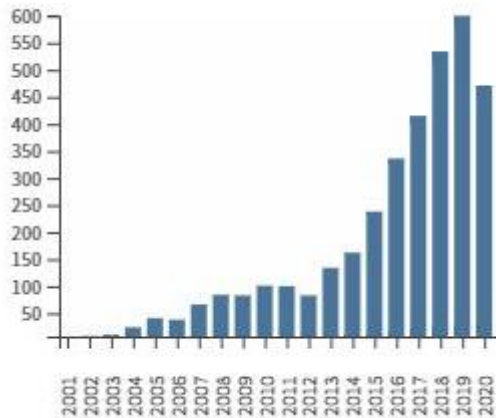
A fast-growing body of research has addressed the ecosystem as a form of inter-firm collaboration. The term goes back to the seminal article by Moore (1993), who laid the foundation for the idea of a co-evolving business cooperation that transcends industry boundaries. However, Moore did not provide an explicit definition but described the phenomenon rather vaguely as a structure in which firms “work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations” (Moore, 1993, p. 76).

Figure 2: Citations of the Term "Ecosystem" per Year



After Moore's seminal article, it took almost 20 years until research on ecosystems gained pace. Figure 2 shows the citation report for the term "ecosystem" in the two categories management and business in October 2020 (data retrieved from Web of Science on 16.10.2020). Similarly, Figure 3 illustrates the rapid increase of ecosystem publications per year in the same categories (data retrieved from Web of Science on 16.10.2020). Remarkably, between 2013 and 2018 alone, the quantity of articles about ecosystems published by the leading journals increased by sevenfold (Jacobides et al., 2018). By the end of 2019, more than 300 articles at the top journals in business and innovation had focused on the "ecosystem" notion, two thirds of which were published since 2015 (Bogers et al., 2019).

Figure 3: Ecosystem Publications per Year

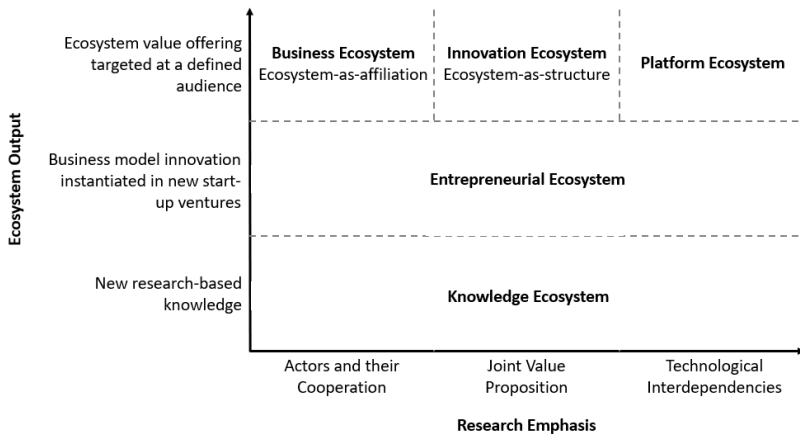


However, the initial blur of the ecosystem concept led to a splitting of different research streams that described distinct phenomena. Varying prefixes, such as *knowledge*, *innovation*, *business*, *platform* or *entrepreneurial ecosystem*, testify to the differentiation of perspectives in the ecosystem literature. Finally, recent studies have provided some conceptual order and clarity on the ecosystem concept (Autio & Thomas, 2020; Jacobides et al., 2018; Thomas & Autio, 2020). My Figure 4, based on Thomas and Autio (2020) and Adner (2017), provides an overview of ecosystem sub-streams in the literature.

The first two broad research streams are knowledge and entrepreneurial ecosystems. The key characteristic of a knowledge ecosystem is the emphasis on collective learning and knowledge exchange processes that advance research-based knowledge (Clarysse, Wright, Bruneel, & Mahajan, 2014; Järvi, Almpantopoulou, & Ritala, 2018; Valkokari, 2015). Thus, in addition to firms, typical participants include universities or research institutions. Entrepreneurial ecosystems usually encompass a regional community of participants and structures that facilitate the start-up and scale-up of new entrepreneurial ventures that compete with innovative business models (Autio,

Nambisan, Thomas, & Wright, 2018; Feldman, Siegel, & Wright, 2019; Spigel, 2017). These participants and structures could be angel investors, mentors, venture capital funds, new venture programs, start-up accelerators, or co-working spaces. However, a joint value proposition for a targeted audience is not part of either knowledge or entrepreneurial ecosystem concepts. This ecosystem-level output is the key conceptual difference in the third major research stream – and this is the direction in which my research moves.

Figure 4: Overview of Ecosystem Sub-Streams



This third research stream has experienced a further differentiation in recent years. However, in this stream the different sub-streams are more difficult to break down, and they are not mutually exclusive since they might cover a similar phenomenon, just with another lens of research.

The two primary sub-streams were described by Adner (2017) as “ecosystem-as-affiliation” and “ecosystem-as-structure”. The former focused primarily on the actors and their cooperation, through which a superior value proposition materializes (Iansiti & Levien, 2004b; Moore, 1996; Nalebuff & Brandenburger, 1996). Scholars of this affiliation stream also introduced the

term *business ecosystem*. In contrast, in the structural stream, scholars have focused on the value proposition as a starting point. This requires a focus on the interdependent activities of actors, which scholars have also addressed as *innovation ecosystems* or *modular ecosystems* (Adner, 2006, 2017; Adner & Kapoor, 2010, 2016; Adner, Oxley, & Silverman, 2013). This ecosystem-as-structure approach also considers actors not directly linked to the orchestrator, and extended the strategic view on ecosystems. The third sub-stream focused on the role of technological interdependencies and introduced the term *platform ecosystem* (Ceccagnoli, Forman, Huang, & Wu, 2012; Gawer & Cusumano, 2014; Giner, Fox, & Cano, 2014; Kindermann et al., 2020). Scholars of this stream explored the governance of this shared connectivity interface, such as standard setting, but maintained this technological view. While the lenses of these three sub-streams are different, the underlying phenomenon might be the same. Perhaps this is the reason I could observe a consolidation of these three sub-streams more recently. Even though the structural stream of Adner appears to prevail over the “affiliation” view in the literature, the single term *ecosystem* starts to replace the two distinct terms *business ecosystem* and *innovation ecosystem* (Aarikka-Stenroos & Ritala, 2017; Adner, 2017; Bogers et al., 2019; Jacobides et al., 2018; Ozalp, Cennamo, & Gawer, 2018; Thomas & Autio, 2020). Reflecting on these recent developments in the literature, I followed the approach of these top scholars above and solely use the term *ecosystem* for this thesis. Also, my studies follow the definition and conception of the structural stream *sui generis* with a focus on the collective ecosystem-level output:

As a baseline, the actors within an ecosystem jointly create a value proposition, which none of these players could achieve in isolation (Adner, 2017; Adner & Kapoor, 2010; Eisenhardt & Galunic, 2000; Hannah & Eisenhardt, 2018; Jacobides et al., 2018; Moore, 1993). In this manner, an ecosystem opens up a wide range of opportunities for firms, such as the development of novel technologies, products or markets, as well as access to resources and competencies that a single company would not have available by itself (Adner, 2006; Kahney, 2004; Moore, 1996). However, a joint value proposition can

only be materialized if it can be broken down into several modules that can be produced independently by the actors involved (Baldwin & Clark, 2000; Jacobides et al., 2018). These complementary modules either increase the mutual value (so-called supermodularity) (Milgrom & Roberts, 1990; Topkis, 1978, 1998) or they are not able to function without each other (Teece, 1986). Thus, the actors must specifically create new modules – or at least mutually adapt existing modules to match the modules provided by the other players (Baldwin & Clark, 2000; Jacobides et al., 2018). By definition, this alignment is multilateral, which means that the connections among the actors cannot be composed along bilateral arrangements (Adner, 2017; Jacobides et al., 2018). Since the mutual adaptation of the modules causes considerable adjustment costs (Adner, 2017; Jacobides et al., 2018), this implies a strong dependency between the actors. Moreover, if one actor fails or leaves the ecosystem, the entire structure is threatened, which is all the more critical since actors in an ecosystem are still independent economic actors with their own individual agenda and goals (Dattée, Alexy, & Autio, 2018; Moore, 1996). This dependency leads to the necessity of at least one orchestrator¹, which is a pivotal firm in charge of involving and aligning partners, and leading them towards novel opportunities, as well as ensuring fair value sharing and proper value creation (Altman & Tushman, 2017; Iansiti & Levien, 2004b; Moore, 1996).

The existing body of research on ecosystems provides several conceptual works that deal with questions related to fields such as strategy (e.g. Eisenhardt & Galunic, 2000; Iansiti & Levien, 2004b), organization (e.g. Kapoor & Agarwal, 2017; Kapoor & Lee, 2013) and innovation (de Brentani & Reid, 2012; Makinen, Kannianen, & Peltola, 2014). However, it remains an open

¹ In this thesis, I use the term “orchestrator” (Altman & Tushman, 2017; Leten, Vanhaverbeke, Roijackers, Clerix, & Van Helleputte, 2013) and do not distinguish between other terms used in the existing literature, e.g., keystone (Clarysse, Wright, Bruneel, & Mahajan, 2014; Iansiti & Levien, 2004), hub firm (Jacobides, Cennamo, et al., 2018; Nambisan & Baron, 2013), focal actor (Adner, 2010, 2016, 2017), or ecosystem leader (Moore, 1996; Teece, 2016).

question how firms can collaborate in ecosystems. Chapters 2.3.1, 2.3.2 and 2.3.3 provide detailed literature reviews and research gaps on the three research subsets of this thesis, namely inter-firm organization and information processing, the role of orchestrators, and the role of complementors. These gaps open promising research opportunities. Furthermore, this concept arouses remarkable interest in industry practice, which is reflected both by other scholars (Atluri et al., 2017; Fuller et al., 2019) and by my own various discussions with practitioners and ecosystem scholars. This offers considerable potential for practitioner-oriented research and the development of tools and specific guidelines on how to collaborate in ecosystems.

2.2 Conceptual Difference to other forms of Organizational Collectives

Despite the enthusiasm of the academic literature and industry practice for the ecosystem concept (see chapter 2.1), one must be careful when empirically exploring the phenomenon of inter-firm collaboration. In my research practice, I repeatedly had lengthy team discussions about whether some cases classify as ecosystems or not. Only when we received a clearer picture of these cases and the nature of the collaborations could we determine precisely what was or was not an ecosystem. This problem demonstrates on a small scale why it is important to have a precise recognition of an ecosystem and its specific characteristics.

Like ecosystems, collaboration between firms per se has become more pervasive over the last decades (Bogers et al., 2019; Fuller et al., 2019). Digitalization has created new opportunities and necessities for companies to share ideas and knowledge and to flexibly combine their outputs (Thomas & Autio, 2020). Consequently, it is crucial for the competitive value creation process for firms to incorporate valuable know-how, ideas, practices and experience from outside the company. Thus, the traditional, firm-centric approach has undergone a massive shift over time towards the current paradigm of opening up the innovation process (Chesbrough, 2006; Enkel et al., 2009; Oh, Phillips, Park, & Lee, 2016). Keywords like “networks” (Ranjay Gulati, 1998), “platforms” (Gawer & Cusumano, 2002) or “open innovation”

(Chesbrough, 2006) have increasingly emerged in the literature. However, based on my experience over the last years, there appears to be a mishmash of wording between the different forms and concepts of inter-firm collaboration, particularly in industry practice. Therefore, it is crucial to understand what makes ecosystems novel and unique in contrast to other forms of organizational collectives.

In short, ecosystems are distinguished from most other types of inter-firm collaboration by their governance systems and the nature of ecosystem outputs (Thomas & Autio, 2020). As such, ecosystems cannot be defined solely by contractual relationships such as supply chains. Instead, enabled by ecosystem roles and shared standards, ecosystem constituents engage in productive interactions that generate a coherent ecosystem-level output (Shipilov & Gawer, 2020). To provide conceptual clarity, Table I provides an overview of related concepts and describes the key conceptual difference to other forms of inter-firm collaboration. This conceptual delimitation is inspired by the recent theoretical underpinnings of Adner (2017), Jacobides et al. (2018), and Thomas and Autio (2020). These underpinnings conceive the key characteristics of an ecosystem as the 1) not fully hierarchically alignment of 2) unique and complementary modules of a 3) multilateral set of heterogeneous partners that 4) jointly create a superior value proposition.

Table I: Key Conceptual Differences of Inter-Firm Collaboration

CONSTRUCT	LITERATURE	DEFINITIONS	CONCEPTUAL DIFFERENCE TO ECOSYSTEMS
PLATFORMS	e.g. Gawer and Cusumano (2002); Gawer and Henderson (2005); Parker, van Alstyne, and Choudary (2016)	“A platform is a business based on enabling value-creating interactions between external producers and consumers. The platform provides an open, participative infrastructure for these interactions and sets governance conditions for them. The platform’s overarching purpose: to consummate matches among users and facilitate the exchange of goods, services or social currency.”(Parker et al., 2016)	<ul style="list-style-type: none"> • A platform can be part of an ecosystem as a technological base, but ecosystems are not necessarily platform based • A platform is only an ecosystem if the modules are unique and complementary • The mutual adaptation of the modules in an ecosystem causes considerable adjustment costs for each additional module
NETWORKS	e.g., Ranjay Gulati (1998); Ozmel, Reuer, and Gulati (2013); Powell, Koput, and Smith-Doerr (1996)	“Networks encompass a firm’s set of relationships, both horizontal and vertical, with other organizations – be they suppliers, customers, competitors, or other entities – including relationships across industries and countries.” (Ranjay Gulati, Nohria, & Zaheer, 2000)	<ul style="list-style-type: none"> • Networks cover the aspect of multilateral relations • But they lack an explicit design and alignment of strategies towards one specific value proposition • They also lack unique and complementary modules
BUSINESS MODELS	e.g., Gassmann, Frankenberger, and Csik (2014); Osterwalder and Pigneur (2005); Zott, Amit, and Massa (2011)	<p>“A business model describes the rationale of how an organization creates, delivers, and captures value.” (Osterwalder & Pigneur, 2005)</p> <p>“A business model describes who the customers are, what goods or services should be offered, how that market offering is created, and why the business is profitable.” (Gassmann et al., 2014)</p>	<ul style="list-style-type: none"> • A business model focuses on the focal firm rather than the constellation of actors • Thus, the level of analysis is the individual firm strategy rather than the value proposition • Further, the business models of partner firms do not necessarily need to be acting in concert • Also, business models do not necessarily have multilateral links between the different partners or an alignment of unique and complementary modules.

SUPPLY CHAIN	e.g., Christopher (1994); Porter (1985); Scott and Westbrook (1991); Simchi-Levi (2008)	“The chain linking each element of the manufacturing and supply process from raw materials to the end user, encompassing several organizational boundaries.” (Scott & Westbrook, 1991)	<ul style="list-style-type: none"> • The interdependencies of the partners involved in the supply chain are mostly characterized by bilateral arrangements and contractual relationships • Multilateral relationships between the partners may exist, but usually in the context of overall fragility • The positions of the actors are fixed and not contested, thus there is no need for an alignment of the orchestrator
OPEN INNOVATION	e.g., Chesbrough (2006); Enkel et al. (2009); von Hippel (2005)	“Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology.” (Chesbrough, 2006)	<ul style="list-style-type: none"> • The concept of open innovation is explicitly concerned with inter-firm interactions and their respective governance • Also, the focus lies on the terms of creation and exchange between the partners • However, the multilateral coordination of several actors is not part of this concept and therefore there is no alignment of unique and complementary modules towards a joint value proposition

2.3 Research Gaps²

Based on the conceptual clarity of the ecosystem concept as described above, it is worthwhile to shift the focus to the research gaps. Given that ecosystem research is still in the early stages, the literature offers promising research opportunities. Some of these opportunities in particular inspired my research. This chapter provides an overview of these areas and synthesizes the addressed research gaps in this thesis. For a concise overview, Table II summarizes these research gaps in the ecosystem literature:

Table II: Summary of Research Gaps that inspired this Thesis

Ecosystem literature still lacks a sufficient understanding of...	
1)	... organizational structures amongst ecosystem actors. ... information processing in ecosystems. ... governance of ecosystems.
2)	... the roles of orchestrators the management of actors in the ecosystem. ... whether and when several players might perform the tasks of an orchestrator .
3)	... the roles and perspectives of complementor firms. ... the dynamics as a central element of an ecosystem. ... interdependencies amongst ecosystem actors.

² Parts of this thesis have been presented at leading scientific conferences (DRUID 2019, ISPIM 2019) and have been submitted in scientific journals with my co-authors Bernhard Lingens and Oliver Gassmann (Strategic Organization, European Management Journal, International Journal of Innovation Management). They contributed substantially with their reviews, edits, changes and feedbacks. I hereby declare that most of the content of the following chapters has been written by myself.

2.3.1 Research Gaps on Information Processing

According to the structural view, ecosystems are groups of organizations that jointly create a value proposition for the customer a single firm could not offer on its own. This value proposition is based on complementary modules provided by the ecosystem partners. Given this complementarity, the partners involved need to mutually adjust their modules in a process of co-specialisation for the joint value proposition to come true (Adner, 2017; Jacobides et al., 2018). This requires information processing among the partners involved, which, in turn, needs firms driving ecosystem initiatives to shape organizational structures amongst the firms involved since information processing is greatly affected by such structures (Galbraith, 1974; Puranam, 2018; Simon, 1997; Tushman & Nadler, 1978). This leads to the question of how firms can shape organizational structures amongst ecosystem partners in a way that information is processed accordingly.

Information processing and organizational design has had a long tradition in research on strategy and organization (for an overview, please see Joseph & Gaba, 2020). However, information processing in the context of meta-organizations such as ecosystems is clearly different yet largely unexplored, which has led to repeated calls for research along these lines (Gavetti, Levinthal, & Ocasio, 2007; Joseph & Gaba, 2020; Ocasio, 1997). From an ecosystem perspective, several works have studied information processing and even organizational structures in the context of digital infrastructures and platform interactions (Ceccagnoli et al., 2012; Hanseth & Lyytinen, 2010; McIntyre & Srinivasan, 2017; Tiwana, Konsynski, & Bush, 2010; Wareham, Fox, & Cano Giner, 2014). However, the distinct characteristics of ecosystems according to the quickly emerging structural view also lead to distinct requirements on the design of inter-firm organizational structures, which have been largely unexplored so far (Jacobides et al., 2018). The few noteworthy studies dealing with such organizational aspects have focused on the effect of organizational structures within firms on the performance of complementor

firms (e.g. Kapoor & Agarwal, 2017) or the investment in new technologies (e.g. Kapoor & Lee, 2013).

Based on the description above, several aspects are crucial for the structural view on ecosystems and make it a distinct concept with distinct implications on the processing of information as well as shaping of organizational structures amongst ecosystem members. These specifics also create the need to develop a distinct view on organizational structures and information processing from the perspective of the structural view, since existing concepts on ecosystems do not embrace these specifics (Adner, 2017; Jacobides et al., 2018).

First, to successfully implement a joint innovation, actors need to pay attention to and process relevant information inside and outside of the ecosystem since they are unlikely to act on opportunities that they are not aware of (Barnett, 2008; Ocasio, 1997). Also, implementation of a joint value proposition requires actors to synchronise their respective contributions, which also requires them to exchange relevant information (Jacobides et al., 2018). In an ecosystem, such information exchange takes place in a setting of multilateral dependency, collaboration, and co-specialization amongst ecosystem partners. Thus, the organizational structures need to allow for a multilateral information exchange as well (Adner, 2017; Jacobides et al., 2018). Because of that, second, one of the key issues related to the management of ecosystems are the significant coordination efforts that come with the co-innovation of several partners that all need to be aligned towards the joint value proposition. All partners need to attend to and process relevant information related to the activities of all or at least most of the other partners. Whilst any processing of information usually causes significant communication costs (Bloom, Garicano, Sadun, & Reenen, 2014; Garicano, 2000), this is likely to be even more the case in a setting of multilateral dependency and communication. Thus, ecosystem actors need to shape organizational structures that balance sufficiency and efficiency in information processing amongst them (Jacobides et al., 2018). Third, given that an ecosystem is not fully hierarchical by its very nature, the orchestrator, as the leading firm and the one shaping the

ecosystem's organisational structures, will try to maintain and secure its position and enforce its agenda in the course of the joint decision making process (R. Gulati et al., 2012; Jacobides et al., 2018; Teece, 2016b). Analogous to the established notion of other, more traditional, organisational settings, it can be expected that the orchestrator will do so by setting organisational structures in a way that the other actors cannot attend to all available information (Gavetti, 2005; Gavetti et al., 2007; Gavetti, Levinthal, & Rivkin, 2005). This goal is running counter to the ones mentioned above since it might exacerbate the processing of information in a way that is best suited for the implementation of the joint value proposition whilst using the overall information capacity efficient as well (Joseph & Gaba, 2020).

Taken together, information processing in an ecosystem setting (according to the structural view) is distinct since it requires optimisation along three interrelated yet independent dimensions: Information processing must facilitate the creation of a joint value proposition and co-specialisation of modules provided by the ecosystem partners. This information processing is inherently multilateral. However, it needs to be efficient to reduce coordination costs whilst allowing orchestrators to secure their position within the ecosystem and manage their partners even without a clear hierarchy being in place. This, also, clearly distinguishes information processing in an ecosystem setting to information processing in more traditional ones (R. Gulati et al., 2012; Joseph & Gaba, 2020; Puranam, 2012).

First, a distinct subset of work examines the role of hierarchy as a key integrating mechanism to limit suboptimal choices (Eggers & Kaplan, 2013; Joseph, Klingebiel, & Wilson, 2016; Rivkin & Siggelkow, 2003; Sengul & Gimeno, 2013; Siggelkow & Levinthal, 2003), but not in a setting with multilateral interdependencies between different organizations. For instance, the literature on supply chains characterizes interdependencies between firms by bilateral arrangements and contractual relationships (Christopher, 1994; Porter, 1985; Scott & Westbrook, 1991; Simchi-Levi, 2008), whereas ecosystems are multilateral and not-fully hierarchical (Adner, 2017; Jacobides

et al., 2018). Thus, the role of hierarchy and multilateral relations leads to a key difference between the logic of ecosystems and this “integration through hierarchy” stream.

Second, a broad stream of literature addresses how organizations adapt knowledge and resources to achieve efficiency, to explore new opportunities, and to innovate (Brusoni & Prencipe, 2006; Fang, Lee, & Schilling, 2010; Helfat & Raubitschek, 2018; Karim & Kaul, 2015; Karim & Mitchell, 2000; Stan & Puranam, 2017). These studies are broadly concerned with interactions between individual decision makers within firms. However, in an ecosystem setting, the decision-makers must interact and process information between firms to co-specialize their modules. This integration through knowledge stream neglects the co-specialization of modules which require a non-fully hierarchical management of ecosystem actors. These characteristics of ecosystems are crucial to understand the unique information processing structures in ecosystems (Joseph & Gaba, 2020). The recent call of Joseph and Gaba reflects this lack of understanding and suggests to revisit the information processing properties of complex systems and explicitly ecosystems (2020). Taken together, information processing in an ecosystem setting is different from that in other inter-firm settings. Given the novelty of these aspects, existing literature has not yet addressed these questions sufficiently, which has led to repeated calls along these lines (Jacobides et al., 2018; Joseph & Gaba, 2020). This thesis is among the first developing a model of how firms can set organizational structures for information processing in an ecosystem setting.

2.3.2 Research Gaps on Orchestrators

As described in chapter 2.1, the presence of an orchestrator firm is a key characteristic of an ecosystem (Adner, 2017; Jacobides et al., 2018). Since all organizations involved in an ecosystem are pursuing their individual agendas and expect a sufficient return on their contributions, the orchestrator needs to align the ecosystem actors towards the joint value proposition (Adner, 2017; Jacobides et al., 2018). For this alignment, the orchestrator must fulfil several

key tasks related to orchestration (Moore, 1993). Despite Moore's early description of the orchestrator's key tasks, the role of orchestrators has remained vague (Jacobides et al., 2018). This raises the question of how firms allocate these orchestrator tasks to specific participants in the ecosystem.

In this section, I illuminate the actual tasks of orchestration. As described above, an ecosystem is defined by the alignment of partners towards a joint value proposition by an orchestrator. Based on this definition, one can define four key tasks that an orchestrator must fulfill. The orchestrator's primary role is the materialization of a joint value proposition (Adner, 2017; Jacobides et al., 2018). In this thesis and based on the observations of the ecosystem cases, I split this key role into two basic tasks. In order to materialize a value proposition, someone must first define it. Thus, I identify the first part of this task as *define value proposition*. The second part of this task – the actual materialization – is called *implement value proposition*. Further, alignment requires “actors’ consistent construal of the configuration of activities” (Adner, 2017, p. 42). I call this third task *coordinate suppliers and partners*, and include the information exchange among actors within this task (Adner, 2017). Lastly, ecosystems are dynamic and not static, and the interdependencies between the actors or even the value proposition might change over time (Aarikka-Stenroos & Ritala, 2017; Moore, 1993). In order to adjust and scale the value proposition, the actors must contribute new ideas to the existing ecosystem (Moore, 1993). In this thesis, I refer to this fourth task as *bring new ideas*. Thus, the four key tasks I derived from the definition of ecosystems are *define value proposition*, *implement value proposition*, *coordinate suppliers and partners*, and *bring new ideas*. These tasks might seem to occur in a delineated sequence, however “in reality, of course, the evolutionary stages blur, and the managerial challenges of one stage often crop up in another” (Moore, 1993, p. 76). Thus, an orchestrator might not address these tasks in a linear order, but rather might tackle them simultaneously (since bringing new ideas, for example, could be beneficial throughout the life cycle of an ecosystem). Beyond these four key tasks, several other minor tasks might be

relevant for the orchestration of ecosystems. In this thesis, however, I focus on these four tasks since they are at the very heart of the ecosystem concept.

Despite the agreement within previous literature that the existence of an orchestrator is one of the key characteristics of an ecosystem (e.g. Alexy, George, & Salter, 2013; Baldwin, 2012; Brusoni & Prencipe, 2013; Leten, Vanhaverbeke, Roijackers, Clerix, & van Helleputte, 2013; Teece, 2016a), the role of orchestrators is still a largely under-researched topic. First, it is still not sufficiently understood how the orchestrator steers the partners as reflected in the recent call of Jacobides et al. that we need “a clearer sense of how ecosystems are structured and governed”(2018). Second, this lack of understanding becomes even more crucial considering the fact that in some ecosystems several players can act as orchestrators. However, the existing literature has addressed these multi-orchestrator ecosystems only rudimentarily, but the important question of whether, and under which circumstances, several players might act as an orchestrator has remained vague (Adner, 2017; Altman & Tushman, 2017; Iansiti & Levien, 2004b; Jacobides et al., 2018; Moore, 1996).

Similarly, despite the early description of an orchestrator’s key challenges in Moore’s seminal work on ecosystems (1993), the existing literature has not elaborated on the distinct tasks an orchestrator needs to fulfil. A noteworthy exception is the study by Brusoni & Prencipe (2013), which mentioned the terms “strategic and operational” to describe the tasks of the orchestrator but did not go into more detail. Thus, even though *comunio litterae* agrees on the importance of orchestrators in ecosystems, the allocation of their tasks has not been sufficiently addressed. In the methods section, I explain how I applied a qualitative multi-case study to address this crucial question.

2.3.3 Research Gaps on Complementors

As described in chapter 2.1, the interdependency and heterogeneity of participants are key characteristics of ecosystems. Thus, it is crucial for my research purpose to consider all the economic actors in an ecosystem.

These actors consist of the orchestrator and immediately adjacent complementors and suppliers, as well as the customer in the sense that the value proposition would not be viable if it did not meet specific customer needs (Thomas & Autio, 2020). In this thesis, I subsume the set of actors “adjacent complementors and suppliers” under the term “complementors”, meaning all the actors that provide independent and complementary modules that need to be aligned towards each other (Baldwin & Clark, 2000; Jacobides et al., 2018). This alignment of non-generic modules represents a key difference between a complementor and a supplier in a supply chain that solely delivers generic goods (Jacobides et al., 2018). Despite the crucial role of an orchestrator, most actors within an ecosystem are complementors (Jacobides et al., 2018). Thus, numerically, all the other actors in the ecosystem that co-create complementary products or services are far more relevant (Altman & Tushman, 2017; Hein et al., 2019; Jacobides et al., 2018; Kapoor & Agarwal, 2017). These actors are critical for the common value creation in an ecosystem (Agarwal & Kapoor, 2017) and it is of utmost importance to secure their engagement (Boudreau, 2012; Eaton, Elaluf-Calderwood, Sorensen, & Yoo, 2015).

This importance results from the fact that the independent and complementary modules of all actors need to be aligned in order to materialize the joint value proposition (Baldwin & Clark, 2000; Jacobides et al., 2018). This mutual adaptation of the modules implies considerable adjustment costs and, therefore, a strong dependency among the partners (Adner, 2017; Jacobides et al., 2018). If one actor fails or leaves the ecosystem, the entire structure is threatened, which is all the more critical since actors in an ecosystem are also independent economic entities with individual agendas and goals (Dattée et al., 2018; Moore, 1996). As such, actors will only stay in the ecosystem when the

rewards or value they receive match or exceed the contributions they make (Barnard, 1971; Simon, Smithburg, & Thompson, 1950). Since every actor has their own agenda, they would each try to minimize their contributions and maximize their rewards, i.e. the value added as a result of being part of the ecosystem. And conversely, the other actors will try to maximize the contributions of complementors. This key contribution-reward trade-off that is part of inter-firm collaborations is particularly crucial for ecosystems due to the multilateral interdependencies of the multiple actors (Adner, 2017). These interdependencies lead to the understanding of dynamics between the partners as a central element of an ecosystem (Aarikka-Stenroos & Ritala, 2017; Moore, 1993; Thomas & Autio, 2014). In other words, the actions of one actor have implications for the other actors in the ecosystem and thus determine their behaviour. This leads to the question of how an individual complementor in an ecosystem approaches the contribution-reward trade-off between itself and the other actors.

Previous research has addressed the success factors of complementors from a holistic ecosystem perspective, such as the importance of independence (T. L. Huber, Kude, & Dibbern, 2017; Song, Xue, Rai, & Zhang, 2018), complementor heterogeneity (Eisenmann, Parker, & van Alstyne, 2011; Jacobides et al., 2018; Wareham et al., 2014), and their balance of complementarity and competitiveness (Boudreau, 2012; de Reuver, Sørensen, & Basole, 2018). Beyond these studies that focus mostly on governance mechanisms and the perspective of the orchestrator, there is still a dearth of research that studies the perspective of the complementors (Agarwal & Kapoor, 2017; Selander, Henfridsson, & Svahn, 2013). Our paper addresses this absence of literature on the role of complementors for the following reasons.

First, existing concepts of interdependent innovation have different focal points than ecosystems, which leaves a conceptual gap (Adner, 2017). For instance, the open innovation literature (Chesbrough, 2006; Enkel et al., 2009; von Hippel, 2005) does not consider the multilateral dependency and

coordination of more than two partners. Similarly, the alliance literature (Ranjay Gulati, 1999; Powell et al., 1996; Walter, Lechner, & Kellermanns, 2008) focuses on the cooperation between partners but does not imply the importance of a joint value proposition.

Second, the multilateral alignment as a crucial aspect of an ecosystem (Adner, 2017; Jacobides et al., 2018) leads to a key difference between the roles of partners in an ecosystem and complementors in platform economies. The platform literature regards complementors (Agarwal, Kapoor, & Baldwin, 2016; Altman & Tushman, 2017) or non-focal actors (Selander et al., 2013) as partners, who are at the periphery of a platform or a digital ecosystem. This implies that first “the digital ecosystem’s survival is not dependent on the non-focal actor’s participation, although the actor may represent an important actor type for the ecosystem. Second, the non-focal actor’s survival is typically not dependent on the specific ecosystem, although the ecosystem may represent an important ecosystem type for the actor” (Selander et al., 2013). In contrast, the “structural stream” defines partners as “actors on whose participation the value proposition depends, regardless of whether or not they have direct links to the focal firm” (Adner, 2017). While a complementor in a platform economy is generic and easily replaceable, the departure of a partner in an ecosystem could threaten the existence of the entire structure. Therefore, the role of a partner in an ecosystem is highly relevant and unique, coinciding with a considerable amount of alignment and, thus, coordination efforts. Existing papers focusing on complementors from a platform perspective (Agarwal et al., 2016; Selander et al., 2013) do not address this multilateral dependency and therefore follow a different logic. Thus, to explicitly consider the interdependency of actors offers promising perspectives for research.

Third, most studies have predominantly applied a purely static view of ecosystems. However, due to the multiplicity of actors and their interdependencies, the understanding of dynamics is a central element of an ecosystem (Aarikka-Stenroos & Ritala, 2017; Moore, 1993; Thomas & Autio, 2014). As such, ecosystem actors need to adjust their contributions over time

to maintain their complementarity with other participants, technologies, and institutions (Thomas & Autio, 2020). Most previous studies have neglected this crucial understanding, which is reflected in the calls of Rong, Shi, and Yu (2013) and Thomas and Autio (2020) for research paying more attention to the dynamics and interactions in the ecosystem, rather than merely focusing on its structure within a certain period. Thus, the literature has neglected these inter-firm dynamics with the other actors in the ecosystem. Therefore, this dynamic perspective opens a deeper understanding of the complementor's role than a purely static view.

Fourth, the existing studies on ecosystems have mostly focused on the perspective of the orchestrator members (Adner, 2017; Altman & Tushman, 2017; Clarysse et al., 2014; Iansiti & Levien, 2004a; Leten et al., 2013; Nambisan & Baron, 2013; Teece, 2016a) and so far have surprisingly neglected the perspective of the partners (Adner, 2017; Jacobides et al., 2018). This one-sided focus on the orchestrator is even more surprising given that participant heterogeneity is one of the key characteristics of ecosystems (Thomas & Autio, 2020) because heterogeneous actors in various roles might have different plans and perceptions regarding the composition of the ecosystem.

For instance Rietveld, Schilling, and Bellavitis (2019) examined various factors that influence the selective promotion of complements and showed complex trade-offs in ecosystem value, but merely focused on the perspective of the orchestrator. The same is true for Kapoor's noteworthy study (2014), which explores the interdependencies and interactions between complementors within the organizational and the strategic contexts and their influence on the pattern and benefits of collaboration. Therefore, regarding the management of complementors, there is still much to learn about their perspective (Adner, 2017; Altman & Tushman, 2017; Kapoor & Agarwal, 2017). Recently, some scholars have started to consider complementors more prominently, mostly for US platform-based ecosystems (Ceccagnoli et al., 2012; Kapoor & Agarwal, 2017; Mantena, Sankaranarayanan, & Viswanathan,

2010; Tavalaei & Cennamo, 2020). For instance, Ozalp et al. (2018) show that complementors are critical for the success of ES, especially in new technologies. However, these scholars have mostly examined firms facing tactical decisions, such as multihoming (Bresnahan, Orsini, & Yin, 2015; Ceccagnoli et al., 2012; Kapoor, 2014; Mantena et al., 2010). Therefore, the perspective of the complementors as a unit of analysis provides a promising lens for research.

As this literature review demonstrates, to date the literature has neglected this important perspective of the individual complementor as well as the inter-firm dynamics with the other actors in the ecosystem. Specifically, it has not yet addressed the research question of how an individual complementor in an ecosystem approaches the contribution-reward trade-off between itself and the other actors, and what the resulting inter-firm dynamics with the other actors are. In order to sufficiently answer this question, I apply a three-layer lens based on the research gaps identified and outlined above. First, I focus on the perspective of the individual complementor as well as its role in the ecosystem. Second, I apply a dynamic perspective and study the changing roles of the complementor, leaving a purely static view of ecosystems. Lastly, I explicitly consider the interdependency of actors as a key characteristic of an ecosystem (Adner, 2017; Jacobides et al., 2018). Thus, I gain a comprehensive view of the ecosystem level and study the resulting dynamics of one actor's changing role and how it affects the other actors.

3 Methods

In order to empirically investigate the three research questions, I applied three qualitative multi-case studies. There were three reasons for choosing this methodology.

First, as described in the literature review, the concept of ecosystems is still not sufficiently understood, incomplete and fragmented, particularly in the areas of inter-firm organization, the orchestration tasks and complementors. Given these circumstances, a qualitative case study design appears most suitable (Eisenhardt, 1989; Graebner, Martin, & Roundy, 2012; Ozcan & Eisenhardt, 2009). The case study enables an in-depth description of a phenomenon to effectively answer “how” and “why” questions (Yin, 2018). Second, I used a multiple-case approach with each case representing one ecosystem. This allowed me to collect comparative data and is likely to provide more accurate and generalisable insights than a single case (Eisenhardt, 1991; Ozcan & Eisenhardt, 2009). Also, since a multi-case study provides rich findings for theorizing and allows for the development of a holistic understanding of unfolding events, it is a preferred research strategy for examining complex social phenomena, such as the dynamics of inter-firm relationships (Duan, 2012). Specifically with regard to organizational structures, this approach helps to understand the nuances of interactions and the consequences from an behavioural perspective (Joseph & Gaba, 2020). Third, the rich empirical insights of this approach strengthens the external validity of a case study (Gibbert, Ruigrok, & Wicki, 2008; Yin, 2018), which might be of particular value for the understanding of the rising ecosystem phenomenon (Eisenhardt, 1989; Ozcan & Eisenhardt, 2009).

For the study on complementors, I adopted an embedded multiple-case study design with each case representing one ecosystem with the *agriculture data company* as an orchestrator. The study had an embedded design since the complementors as a subunit within each case were nested in the greater context of the *agriculture data company* network (Yin, 2018). This was particularly

beneficial for my research purpose, since an embedded case design illuminates the case using within case analysis (within the complementors separately), between case analysis (between the complementors), and cross-case analysis (across all of the complementors) (Baxter & Jack, 2008). Adopting an embedded multiple-case study approach to conducting research allowed for consideration of this nested context during the exploration of the complementors of the ecosystems.

3.1 Data Sampling

To select the cases for the three multi-case studies I applied several criteria. First, all ecosystems studied must correspond to the structural ecosystem view being used in this thesis (Adner, 2017; Jacobides et al., 2018; see also Thomas & Autio, 2020). Applying this lens, one can identify the boundaries of an ecosystem and, thus, whether firms are part of the ecosystem or not. Hence, firms are only ecosystem participants if they offer a unique and complementary contribution to the joint value proposition. As such, firms 1) are engaged in multilateral relationships which cannot be fully broken down into independent bilateral relations, 2) are aligned by an orchestrator to a fully developed and clearly describable value proposition and 3) their modules to this value proposition are characterized by non-generic complementarities.

Second, was the selection of ecosystems “with an understanding of where there was likely to be variation and where there was not” (Ott, Eisenhardt, & Bingham, 2017, p. 86). For instance, I ensured that there was a certain variety within the cases in terms of background, value proposition, and the company size of the orchestrator. Moreover, the patterns of orchestrators in the ecosystems I studied included established firms and spin-offs as well as start-ups.

Third, ecosystems are usually industry-crossing organizations (Moore, 1993), which makes it less likely that the findings are being distorted by industry specifics (Adner, 2017; Jacobides et al., 2018). The same patterns of partners (e.g. software company, service company, etc.) occur in all of the three case

studies, so each ecosystem has a similar partner structure, which allows for comparability among the cases and also enabled a stronger pattern recognition (Eisenhardt & Graebner, 2007). In addition, all value propositions belong to the same cluster, digital services. This sampling approach to form a common cluster resembles ones that have been used by prior studies on ecosystems and related subjects (e.g. Chatman & Jehn, 1994; Davis, 2016; De Wulf, Odekerken-Schröder, & Iacobucci, 2001; Dedehayir & Mäkinen, 2013; Frankenberger & Sauer, 2018; Rong, Hu, Lin, Shi, & Guo, 2015; Schoenecker & Cooper, 1998).

In general, I used an iterative approach implementing constant adjustments between case selection, data collection, and data analysis (Eisenhardt, 1989). For instance, for the first study the initial set consisted of around 20 short cases of which, based on my sampling criteria, I selected five as an initial sample. After having conducted the first rounds of interviews and data analysis, I was searching for additional cases to extend and enrich my sample, as well as to yield a better understanding of the emerging theory (Eisenhardt, 1989). Likewise, I excluded cases from the sample that proved not to ideally match the criteria, until I reached a state where additional cases no longer significantly enriched the understanding of the context (Eisenhardt, 1989).

The study of complementors consists of three cases within the *agriculture data company* network. Each case had a distinct value proposition and different partners were involved. The *agriculture data company* acted as the orchestrator in all these cases. The value propositions were developed in the agriculture sector. This sector is particularly relevant for the research focus on complementors because 1) a large variety of innovations is currently being developed (e.g. hardware, machinery, seeds, data analysis), and 2) this requires both digital and traditional non-digital companies to cooperate, and 3) these companies are diverse in terms of size, core competencies, and their traditional industrial backgrounds. This diversity between the complementor firms makes it an “extreme case” (Eisenhardt, 1989; Pratt, Rockmann, & Kaufmann, 2006). Extreme cases and polar types enable greater observability of contrasting patterns in the data and stronger pattern recognition (Eisenhardt & Graebner,

2007), which is particularly valuable for studying different complementors. Moreover, extreme cases facilitate theory building, as the issues being examined tend to be more visible than in other contexts (Eisenhardt, 1989; Pratt et al., 2006).

3.2 Overall Description of Cases

This section illustrates the case samples used for the three studies. To ensure better clarity and comparability, most information is presented in tabular form. Table III provides the following information based on the structural view of the ecosystem (see chapter 3.1): Each case is first described in a structured way by its joint value proposition. Subsequently, the ecosystem actors and their non-generic modules are presented. These modules are concisely listed as contributions of actors. Additionally, the second column shows for which study the respective case was used. While some cases were only used for the first study, other cases offered such a rich database that they were suitable for two research foci. Thus, the cases Digital Access, SME Factoring, Drone Delivery, Autonomous Mobility and Customized Relocation provided initial insights into the organizational structures as well as starting points for an in-depth study on orchestrators. Conversely, the Connectivity Services case provided not only in-depth insights into the perspective of the complementors but also detailed insights about the orchestrators. The final sample of cases used in this thesis, as well as a short description and an overview of the contributions of each actor, is shown in Table III.

For the embedded multi-case study about complementors (see chapter 3.1), I decided to collect three in depth-cases. This allowed me to go even deeper into the cases and illuminate each complementor in sufficient detail. As briefly described in the previous chapter, all three cases are embedded in the network of the *agriculture data company*. The *agriculture data company* is a leading company in the field of digital modelling and data processing and the development of decision support for agriculture. Together with its partners, the small company develops digital solutions to increase productivity and sustainability. The *agriculture data company* works closely with research and

industry partners on an interdisciplinary basis to quickly bring innovative applications to market. Its core competence lies in the modelling and processing of complex data structures and the development of decision-making aids based on them. Due to the professional background of the two founders (a farmer who worked as a middle-manager for a crop-protection company and a manager of a consulting firm), the *agriculture data company* has know-how in both agriculture and technology. Networking with the partners and the common use of know-how is indispensable for the start-up, which only has limited resources at its disposal (initially 16 FTE).

In order to create the different value propositions, the *agriculture data company* builds cooperations with other partners. Three of these cooperations meet the criteria of an ecosystem (see chapter 3.1). In all three ecosystems, the *agriculture data company* acts as orchestrator. These ecosystems include at least three actors that operate within different industries and vary in terms of size. The complementors are sometimes also partly involved in several ecosystems (*research institute*). Table IV shows a rationale of which actors classify as orchestrators, complementors or simply suppliers in these three cases. I provide more detailed information regarding the cases in the findings section.

Table III: Overall Descriptions of the Cases³

<i>Case</i>	<i>Data used for study</i>	<i>Description</i>	<i>Actors</i>	<i>Contributions of actors</i>
<i>Digital Access</i>	1 + 2	<p>The value proposition in the Digital Access Case lies in a digital solution that allows customers to open doors of rooms, buildings, cars etc. by using a temporarily valid smartphone code. Thus, there is no need for the exchange of keys, which is particularly beneficial in the context of shared goods. Therefore, one of the most important use cases (in addition to some others for which the orchestrator has different employees and partners) provides keyless digital access to rental cars. In order to unlock cars via a smartphone, the car rental company technically modified its cars for the new system and developed a mobile app for the end customers. Further hardware and software solutions had to be implemented into the car fleet by the other ecosystem partners. For this purpose, the players mutually adapted their modules in order to synchronize the software, hardware, and service components.</p>	<i>Service Provider (Cloud Service)</i>	Payment, coordination, app, database, cloud (app customized for car rental company)
			<i>Access Provider</i>	Rights to use technology, software matching with hardware
			<i>Partner</i>	Money for driving rent
			<i>Car Rental Company</i>	Money for service, payment support for damages, coordination, renting vehicle

³ This dissertation contains case data which was partly also used for other projects of our research group at the Helvetia Innovation Lab. Therefore, descriptions and raw data from some cases have been partially used in other publications of my colleagues and thus can bear striking resemblance to my own work.

			Box Supplier (Hardware)	Revenue share, hardware and installation service, test function, dependence, technology
SME Factoring	1 + 2	<p>The SME Factoring Case provides a factoring service for Swiss Small and Medium Enterprises (SME) operating in developing countries. In this business environment, the payment deadlines are very long (often up to 180 days), which can be a severe issue for the liquidity of these companies. Regular factoring addresses this problem but is usually only granted to SMEs that have an adequate level of liquidity. Other companies, however, are excluded from factoring and thus have difficulties operating in these developing countries. This problem is solved by a FinTech company, which provides a tailor-made factoring solution specifically for SMEs with low liquidity and poor credit ratings. In order for this value proposition to be realized, the FinTech company built an ecosystem that interlinks various actors: Through the intermediation of a FinTech company, banks ensure that customers have access to a credit line. Multiple investors provide the monetary funds for the factoring in exchange for interest. An insurance company takes over the risks of payment default. An insurance broker ensures a continuous exchange of information with the insurance company and provides know-how, reputation and sales to the FinTech company. Lastly, a software developer provides an algorithm that scans through all claims of the respective SMEs to assess and categorize the risks of their claims.</p>	Funding Partners	Money (credit line)
			FinTech Company	Interest, insurance of accounts receivable, credit line, interest, provision as % of insurance premium, money as % of credit sold
			Customers (SME)	Accounts receivable, interest, insurance premium
			FinTech Company	Access to customers, money (credit line), already established relationship
			Investors	Continuous exchange of information with insurance company, know-how, reputation, sales
			Insurance	Already worked together with software developer, continuous exchange of information with insurance broker, insurance of funding and credit line, intro of software developer

			<i>Software Company</i>	Development of platform, already worked together with insurance company
<i>Drone Delivery</i>	1 + 2	In the Drone Delivery Case, the ecosystem provides delivery of goods executed by an autonomous drone. The key partners, which developed this value proposition, were originally a logistics company, a flight cargo company (which later left the ecosystem) and a drone technology provider. Furthermore, a hospital provided the use case as well as a test ground, knowledge and experience on logistics. Lastly, governmental authorities were involved as well in the ecosystem and created a legal foundation for the autonomous flying drones. The current focus of the ecosystem lies on the transport of sensitive and high value medical objects (e.g. organs, blood, etc.) from one hospital to another.	<i>Logistics Company</i>	Reputation, communication, money, know-how about logistics, reduced price
			<i>Hospital (Customer)</i>	Test ground knowledge on hospital logistics, money
			<i>Flight Cargo Company (Withdraw)</i>	Money, know-how about cargo logistics
			<i>Drone Technology Provider</i>	Drone technology, information on drones, drone hardware
			<i>Governmental Authorities</i>	Regulation
<i>Autonomous Mobility</i>	1 + 2	The Autonomous Mobility Case ecosystem provides an autonomous driving bus in pedestrian zones. Five core players collaborated and created a structure for common projects, into which additional actors are integrated when needed. A public transport provider contributed knowledge and experience, particularly pertaining to the processes of public transportation. University 1 provided expertise regarding Big Data and several start-ups, which are specialized in the areas of autonomous driving (e.g. fleet management programmer or manufacturer of Autonomous Mobilities). By contributing data analytics towards a fleet management programmer, it further enables the fleet	<i>University 1</i>	Data analytics
			<i>University 2</i>	Software (app), questionnaire on user experience

		<p>management of the autonomous driving public transportation. University 2 brought in market knowledge and a network, as well as market research. In addition to these players, a city provided the test ground and a Canton dealt with the federal authority for regulations. Governmental authorities establish regulations for the bus manufacturers and autonomous driving public transportation. Supported by the public transportation provider, the bus manufacturer provides governmental authorities with information and contributes the buses for the autonomous driving public transportation.</p>	<p>Canton</p>	<p>Beta users, road traffic office support, lobbying</p>
			<p>Bus Manufacturer</p>	<p>Information, buses</p>
			<p>Fleet Management Programmer</p>	<p>Fleet management</p>
			<p>City</p>	<p>Beta users, test ground</p>
			<p>Public Transport Provider</p>	<p>Infrastructure, public transportation, communication, support, finances, public transportation provider knowledge</p>
<p>Customized Relocation1 Customized Relocation2 Customized Relocation3</p>	<p>1 + 2</p>	<p>In the Customized Relocation Case, the value proposition is a personally tailored relocation process for the end customer. Specifically, the ecosystem addresses all aspects around relocation and provides a solution in which customers are no longer required to deal individually with each of the companies involved in the relocation process. This process encompasses the actual move and cleaning, as well as the transport and sales process for furniture etc. Furthermore, customers receive additional benefits, such as a free and tailor-made insurance service for the household, provided by an insurance partner. For the purpose of our investigation, we split the case into three phases, since the orchestrator handled the organization of the ecosystem very differently over time. Initially as a new start-up, provision of the core services was manually laborious and barely included any technical support for partner communication. We define this initial phase as Customized Relocation1. However, with the implementation of a platform, coordination between the key partners became largely automated. This platform also meant that the employees of the orchestrator now had more remaining time that they could focus on potential additional services. We define this later phase as Customized Relocation2. Additionally, for aspects of a relocation that are not close to the move, the</p>	<p>Relocator Platform</p>	<p>Customers, money, distant moving leads, orders, visibility, leads, orders, mediation of moving company (incl. whole package)</p>
			<p>Business Development Partners</p>	<p>Services, commissions, money, reputation</p>
			<p>Moving & Cleaning Company</p>	<p>Cleaning, moving, proximal moving, leads, orders</p>
			<p>Customers</p>	<p>Money, orders</p>

		orchestrator hands over the client to a partner, which uses its own system instead of the orchestrator’s platform. We define this lead model as Customized Relocation ³ . Core players that contribute to the value proposition – business development partners and a moving and cleaning company – and customers are all interlinked through a relocator platform. An insurance company insures the customer for any insurance cases that can occur during the moving phase. Software provider 1 forms an interface with the insurance company, whereas software provider 2 is responsible for building the relocator platform. The actors are characterized by their multilateral dependency. Marketing activities are supported by a marketing partner.	<i>Insurance Partner</i>	Product integration, insurance
			<i>Software Provider</i>	IT enabling
			<i>Marketing Partner</i>	Leads
			<i>Software Provider</i>	Software
<i>Review Video</i>	1	The value proposition of the Review Video Case provides customized and independent product-review videos to publishers, who can embed these reviews into their websites and internal systems to be watched by end customers. A community of video and product experts, who are instructed and guided by the Video Company, creates these reviews for specific products from the publishers. The Video Company edits and analyses this material, thus optimizing its database. Additionally, the publishers require specific videos and, importantly, data and information about how to optimize the appearance of its videos for the end customers. In order to incorporate the material into their systems, the publishers must adapt their infrastructure.	<i>Video Company</i>	Video content, consumer data, share of revenue, support
			<i>Video & Product Experts</i>	Production, right of use, authentic product information
			<i>End customers</i>	Revenue, data, reach
			<i>Publishers</i>	Revenue by license costs, affiliate purchase, independent reviews
<i>Product Insurance</i>	1	In the Product Insurance Case, the ecosystem combines a physical product with a customized insurance solution. Specifically, to create a customized insurance platform for a B2C corporation, the insurance intermediary brings together the product of an established insurance company and a B2C company, which produces physical products.	<i>Insurance</i>	Commission, insurance coverage

		<p>This way, the customer reports possible damage directly to the insurance intermediary. Thus, the insurance is fully implemented into the sales process of the physical product. One exemplary use case combines a smart toothbrush with an insurance for teeth.</p>	<i>Customers</i>	Damage, cash, data
			<i>B2C Corporation</i>	Insurance, contract, data
			<i>Insurance Intermediary</i>	Cash, data, contract, customized insurance, platform
<i>Peer-to-peer Carsharing</i>	1	<p>The value proposition of the Peer-to-peer Carsharing Case is a peer-to-peer carsharing opportunity. Hence, the core of the ecosystem is a platform built and maintained by the Renting Platform. With the use of this technical solution, private lessors and tenants are capable of interacting, though employees from the Renting Platform usually personally assist them throughout the process. An independent insurer provides an insurance solution for the rented cars. In addition to these core partners, there are several other players, such as garages, petrol stations, credit partners or supermarkets, which provide additional services or benefits for the tenants or private lessors.</p>	<i>Renting Platform</i>	Platform, annual car fee, data, placement community, cash
			<i>Tenants (Customers)</i>	Cash, refuel, profile
			<i>Credit Partners</i>	Leasing, leasing access
			<i>Supermarkets</i>	Marketing, points
			<i>Garages</i>	Build box
			<i>Petrol Stations</i>	Fuel, preferential terms, fuel access

			<i>Private Lessors</i>	Car, contact
			<i>Independent Insurer</i>	Insurance police, bonus protection
Connected City	2	In the Connected City Case, the value proposition refers to the overall customer mobility journey for commuters in cities and suburbs. The initiator of the ecosystem is a European car manufacturer. Other co-orchestrators include a global consulting firm that provides the management skills and a network of contacts, and a world-leading software company that contributes communication skills and data-processing technologies. In the process of further developing the ecosystem, other partners (e.g. city administrations) are involved in order to improve and expand the services offered.	<i>Car Manufacturer</i>	Know-how: mobility
			<i>Consulting Firm</i>	Management skills, network
			<i>Software Company</i>	Communication skills and data-processing technologies
			<i>Public Partners</i>	Beta Users, test ground
Disease Detection	3	The value proposition in this case lies in disease detection and pest control in viticulture. This is done by data analysis from a customer-specific hyperspectral camera. Through frequent multilateral and bilateral exchanges between the partners of an agriculture data company, an application-oriented research institute, and the viticulture institute, a solution is jointly developed. Furthermore, the employees of the respective partners were physically present at the winery several times.	<i>The agriculture data company</i>	Know-how: digital modelling, data processing
			<i>Research Institute</i>	Know-how: sensor technology, Data processing
			<i>Vineyards</i>	Know-how: oenology, Testing grounds, crop assessments

			<i>Viticulture Institutes</i>	Know-how: oenology, viticulture and how things have been developed and done
			<i>Hyperspectral camera supplier/ Drone supplier</i>	Drones, hyperspectral camera
Connectivity Service	2 + 3	<p>The value proposition of this case represents an innovation platform with the open source concept, which connects partners across industries. Agricultural machines, sensors, and algorithms are combined by the respective partners by connecting specific interfaces (e.g. satellites, platforms, machines, stables, milking robots, or cameras). This also ensures that the farmer can decide very flexibly which machine is combined with which sensor and which data analysis platform. Furthermore, there are several use cases for the performance product, e.g. automated irrigation for monitoring plant stress, disease detection in viticulture, and the detection of the nervousness level of animals. Despite the occasional exchange between all the partners, the <i>agriculture data company</i> usually functions as a nodal point in the middle between the partners and consciously takes the position of orchestrator. To ensure technical connectivity, the partners build technical interfaces between their modules.</p>	<i>The agriculture data company</i>	Know-how: digital modelling, data processing
			<i>Research Institute</i>	Know-how: laser scan analysis
			<i>Other research institutes</i>	Know-how AI systems
			<i>Machine manufacturers</i>	Know-how: use cases for machines and machine data
			<i>Farmers</i>	Know-how: use cases for agriculture and agricultural facilities
			<i>Drone and sensor technology operators</i>	Drones
			<i>Data service provider</i>	Data services

			<i>Sensor provider</i>	Sensors
Growth Regulation	3	The value proposition in this case is a growth regulator module that provides insights and uses an individually adapted and customized solution for each plant. Thus, farmers can get the most from the plant and protect it against wind and weather. Four key actors collaborate to develop this solution. The <i>agriculture data company</i> and a research institute provide data and digital modelling know-how. Additionally, a chemical company contributes know-how about chemical pest control and several farmers provide testing grounds and their specific farming expertise with regard to these crops.	<i>The agriculture data company</i>	Know-how: digital modelling, data processing
			<i>Research institute</i>	Know-how, data
			<i>Chemical Companies</i>	Know-how, chemical pest control
			<i>Farmers</i>	Testing grounds

Table IV: Actor Classification of Cases for Complementor Study

Case	Actor	Classification	Rationale
Disease Detection	The agriculture data company	Orchestrator	The partners are led and coordinated by the <i>agriculture data company</i> and jointly developed the solution. They exchanged knowledge and frequently exchanged multilateral and bilateral coordination. Employees of the agriculture data company, the research institute, and the viticulture institute were physically present at the vineyard several times in order to coordinate.
	Research Institute ⁴	Complementor	
	Vineyards	Complementor	
	Viticulture Institutes	Complementor	
	Hyperspectral camera supplier/ Drone supplier	Suppliers	Drones and hyperspectral cameras are standardized products and thus generic modules.
Connectivity Service	The agriculture data company	Orchestrator	In order to create an overarching connectivity system, all the partners need to collaborate and create interfaces to their individual systems. The 30 partners in the consortium know each other. Naturally, there are some key players who are more involved in the overall communication than others. These have almost daily contact in the form of emails or phone calls and meet physically from time to time. The <i>agriculture data company</i> is responsible for the software architecture of the overall system as well as the interfaces with the farmers. This makes the <i>agriculture data company</i> a decisive node between partners. Also, the research institute plays a major role in project coordination and went from being a complementor to a co-orchestrator.
	Research Institute	Orchestrator	
	Other research institutes	Complementor	
	Machine manufacturers	Complementor	
	Farmers	Complementor	

⁴ The *research institute* acts as complementor in the Disease Detection case but as co-orchestrator in the Connectivity Service case. For a detailed description and rationale, please see chapter 4.3.

	Drone and sensor technology operators	Suppliers	The operation of drones & sensors as well as the provision of data service and sensors are standardized services or products and therefore generic modules
	Data service provider	Suppliers	
	Sensor provider	Suppliers	
Growth Regulation	The agriculture data company	Orchestrator	To develop the growth regulator module, all partners contributed and exchanged their specific know-how. Operationally all partners were connected via the online tool of the agriculture data company, including the farmers, and had to add specific data.
	Research institute	Complementor	
	Chemical Companies	Complementor	
	Farmers	Complementor	

3.3 Data Collection

My data collection process was structured along five main steps and took place from January 2018 to September 2020. It should be noted that the collected data of the cases was sometimes also used for other projects of the research group at the Helvetia Innovation Lab. Therefore, it is possible that the descriptions and data from some of the cases will also partially be used in publications of my colleagues. The joint data collection in a research group has proven to be particularly useful in qualitative ecosystem research (Dattée et al., 2018). Thus, my colleagues were occasionally also present or involved in the data collection process and we conducted joint interviews in pairs, for example. On these occasions, we recorded and transcribed the interviews verbatim and independently took detailed notes and analysed the information (Mayring, 2007). Additionally, we sketched graphical representations of the ecosystems together with the respondents (Dattée et al., 2018).

First, I conducted initial interviews (between 15–60 minutes) with the main contact person from the ecosystem orchestrator to gain an initial understanding of the ecosystem. Second, I enriched these initial findings with semi-structured interviews (60–90 minutes) with additional executives from each orchestrator firm, choosing executives who have an excellent overview of their respective ecosystems. The data collection started with the orchestrator firm from each ecosystem, and identified the orchestrator based on our prior external analysis both with publicly available information and bilateral communication with people involved in the ecosystem. I chose the orchestrator as a starting point since this firm is in charge of defining partner activities and the organizational structures between them (Adner, 2017; Moore, 1993; Teece, 2007, 2016a), and also because the orchestrator can be considered the actor with the most extensive overall view of the ecosystem and the information flows between ecosystem members (Adner, 2017; Jacobides et al., 2018; Moore, 1993).

In the third step, I interviewed actors from non-orchestrator firms within the same ecosystems to further enrich the findings by incorporating views from

complementor companies. I chose these complementors based on if it was necessary to extensively discuss the perspective of these firms to supplement or triangulate the information provided by the orchestrator about the overall information processing structure. With the exception of the Review Video and Connected City cases I was able to speak with complementors in all cases. In the former case I did not gain direct access to the other partners but could retrieve extensive insights and internal documents such as emails or newsletters for publishers. Also, the Review Video represents a pattern, which is also covered by the SME Factoring, Customized Relocation¹ and Product Insurance cases, which are based on several partner interviews. My three questionnaires are included in the appendix (Appendix 1, Appendix 2 and Appendix 3).

Fourth, I collected extensive supplementary data, which consists of both external and (orchestrator-) internal documents, as well as documents provided by third parties about the ecosystem and other aspects, which were addressed in the initial questionnaire. These documents include press releases, media reports, homepages, and annual reports, as well as internal presentations, reports and emails, and helped to gain an understanding of the formal cooperation agreements in particular. This enabled me to enrich the insights gained during the interviews and to validate and triangulate those insights (Jick, 1979).

Thereafter, in order to further deepen the existing findings and disentangle eventual inconsistencies or misunderstandings, I conducted another round of interviews with the orchestrator firm, and asked for additional information via email and short follow-up calls. Additionally, our research group conducted workshops with some of the companies, which enabled me to collect further information and check for consistency between emerging theoretical constructs and practitioners' perceptions of how the ecosystems worked. For instance, I asked employees of the orchestrator firms to sketch the information flows between ecosystem partners, thus challenging our initial understanding of these flows.

Table V gives an overview of the data sources of this thesis, structured per case. Since the complementors represented the unit of analysis in the third multi-case study, I additionally presented the specific data on the individual actors in Table VI in more detail. This is particularly necessary since the two actors *agriculture data company* and *research institute* are acting simultaneously in two and three ecosystems, respectively, and have therefore covered more than one case in these interviews. For the sake of consistency, these interviews are therefore included in

Table V for each case, but they are of course only counted once.

Noteworthy, in the course of the interviews for the complementor study, I recognized three structures that meet the criteria of an ecosystem. Other cooperations with the *agriculture data company* emerged as simply bilateral partnerships or pure research projects without specific value propositions. I therefore could not include the interviews with these non-ecosystem partners in my primary data sources (displayed in

Table V and Table VI), although they clearly helped me to gain a better understanding of the *agriculture data company* network as well as the interactions with the partners.

Table V: Case and Data Overview of this Thesis

<i>CASE</i>	<i>BUSINESS FIELD</i>	<i># INTERVIEWS</i>	<i>INTERVIEWEE POSITION</i> O = ORCHESTRATOR COMPANY C = COMPLEMENTOR COMPANY	<i>INTERVIEWEE LETTER-NUMBER CODE</i> ⁵	<i>INTERVIEW DURATION (MIN)</i>	<i>ADDITIONAL DATA</i>
DIGITAL ACCESS	Security	6	1. CEO 2. CSO (O) 3. Head Ecosystems & Venturing (C) 4. Venture Fund Manager (C)	A1 A2 A3 A4	67+21+63 81 65 21	Company website documents (internal) Blog posts & online articles (external)
SME FACTORING	Finance	8	1. CEO (O) 2. Head of Marketing (O) 3. Innovation Manager (C)	F1 F2 F3	139+32+37 81+23+27+22 36	Company website documents (internal) Online articles about the orchestrator (external)
DRONE DELIVERY	Logistics	8	1. Head of Autonomous Delivery (O) 2. Head of Open Innovation (O) 3. Program Manager (O) 4. Project Manager (O) 5. Chief Physician (C) 6. CEO (C)	D1 D2 D3 D4 D5 D6	36+60+60 53 55 36 28 39	Company website documents (internal) Expert board final report (internal) Blog posts & online articles (external)
AUTONOMOUS MOBILITY	Public transportation	7	1. Head of Open Innovation (O)	M1	52	Company website documents (internal)

⁵ The letter-number codes identify individuals (abbreviated pseudonym) and by an assigned number.

			2. Head Project Lab (O) 3. Lab Coordinator 4. Head of Strategy & Innovation (C) 5. Operational Director (C)	M2 M3 M4 M5	75+48 45+13 57 26	Technical report (internal) Newspaper, online articles & TV reports (external)
CUSTOMIZED RELOCATION	Home	9	1. Key Account Manager (O) 2. Business Development Manager (O) 3. Founder & CEO (O) 4. Head of Business Development (O) 5. Innovation Manager (C)	R1 R2 R3 R4 R5	9+66 85+75 66+61 26+24 40	Company website documents (internal) Participant observation in workshop (internal) Online & magazine articles (external) Newspaper articles (external)
REVIEW VIDEO	Media	4	1. COO & Co-Founder (O) 2. CTO & Co-Founder (O)	V1 V2	32+29+23 37	Company website documents (internal) Blog posts & online articles (external) Internal newsletters (internal)
PRODUCT INSURANCE	Insurance	5	1. CEO (O) 2. COO (O) 3. Head of Strategy and Planning (C)	I1 I2 I3	38 + 31 41 + 30 51	Company website documents (internal) Blog posts & online articles (external) Radio & TV reports (external)
PEER-TO-PEER CARSHARING	Mobility	6	1. CEO (O) 2. Head Ecosystems (C)	C1 C2	39 + 41 25	Company website documents (internal)

			3. Car Tenant (C) 4. Car Lessor (C) 5. Car Lessor (C)	C3 C4 C5	22 18 24	Internal Company presentation (internal) Radio & TV reports (external)
CONNECTED CITY	Mobility	2	Head Ecosystem Initiative (O)	B1	52+34	Company website documents (internal) Internal Company presentation (internal)
DISEASE DETECTION	Agriculture	10	1. CEO & Co-Founder (O) 2. Chairman & Co-Founder (O) 3. CEO (C) 4. Project Leader (C+O)	AG1 AG2 H1 H2	74+33+49+31+46 39 39+36 18+23	Company website documents (external) Blog post & online articles (external) Data Tools (internal) Research Publications (external)
CONNECTIVITY SERVICES	Agriculture	11	1. CEO & Co-Founder (O) 2. Chairman & Co-Founder (O) 3. Project Leader (C+O) 4. Alliance Manager Europe (C) 5. Electronic Markets Lead (C)	AG1 AG2 S1 S2 S3	74+33+49+31+46 39 18+23 27 24+21	Company website documents (external) Blog post & online articles (external) Data Tools (internal)
GROWTH REGULATION	Agriculture	8	1. CEO & Co-Founder (O) 2. Chairman & Co-Founder (O) 3. Head of Crop Enhancement (C)	AG1 AG2 GR1	74+33+49+31+46 39 34+39	Company website documents (external) Blog post & online articles (external)

						Data Tools (internal)
TOTAL		70 ⁶			2,950	

Table VI: Detailed Data Overview of Complementor Study

ACTOR & ROLE O = ORCHESTRATOR COMPANY C = COMPLEMENTOR COMPANY	BUSINESS FIELD	CASES	# INTERVIEWS	INTERVIEWEE POSITIONS	INTERVIEWEE LETTER- NUMBER CODE	INTERVIEW DURATION (MIN)	ADDITIONAL DATA (SOURCE)
AGRICULTURE DATA COMPANY (O)	Agriculture	Growth Regulation; Connectivity Services; Disease Detection	6	1. CEO & Co- Founder (O) 2. Chairman & Co-Founder (O)	AG1 AG2	74+33+49+31+46 39	Company website documents (external) Blog post (external) Data Tools (internal)
VINEYARDS (C)	Agriculture	Disease Detection	2	1. CEO (C)	H1	39+36	Company website documents (external)
RESEARCH INSTITUTE (C)	Technology	Connectivity Services; Disease Detection	2	1. Project Leader (C+O)	H2	18+23	Company website documents (external)

⁶ As described in chapter 3.3 the two actors *agriculture data company* and *research institute* are acting simultaneously in two and three ecosystems, respectively, and have therefore covered more than one case in these interviews. For the sake of consistency, these interviews are therefore included for each case, but they are only counted once.

							Research Publications (external)
CHEMICAL COMPANY (C)	Agriculture	Growth Regulation	2	1. Head of Crop Enhancement (C)	GR1	34+39	Company website documents (external) Online articles (external)
MACHINE MANUFACTURER 1 (C)	Machinery	Connectivity Services	1	1. Alliance Manager Europe (C)	S2	27	Company website documents (external) Blog post & online articles (external)
MACHINE MANUFACTURER 2 (C)	Machinery	Connectivity Services	2	1. Electronic Markets Lead (C)	S3	24+21	Company website documents (external) Online articles (external)
TOTAL			15			533	

3.4 Data Analysis

In all three studies, I created individual cases as a foundation for the cross-case analysis (Yin, 2018), which was initialised with an open mind and without pre-defined hypotheses (Eisenhardt, 1989).

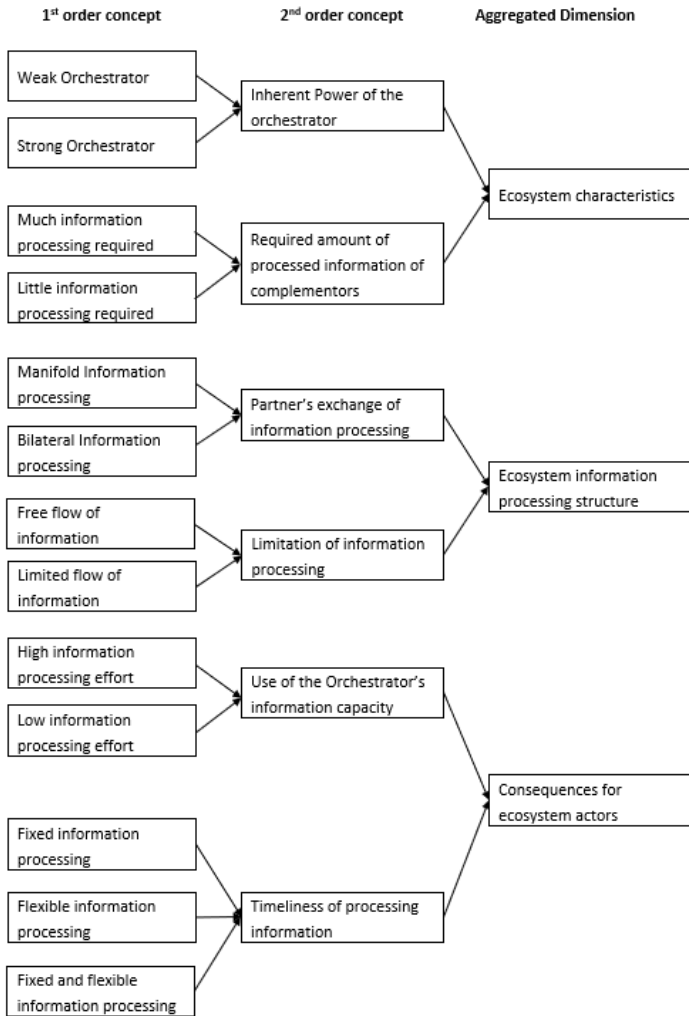
As such, in the first study, I searched for high-level themes in the interview transcripts that referred to the information processing structure of the ecosystem, e.g. ‘communication’, ‘partner’, ‘exchange’, ‘information’ or ‘coordination’. I made use of drawings, tables, and other forms of visualisation (Miles & Huberman, 1994; Yin, 2018), and adopted an inclusive and open-coding approach (Strauss & Corbin, 1998) to gain an overview of the content and to detect patterns in the data more easily. For the same reasons, I paired cases in order to understand similarities and differences between the cases (Ozcan & Eisenhardt, 2009). On this basis, I developed first constructs in a recursive manner (Eisenhardt & Graebner, 2007), representing elements of information processing as well as key aspects of organizational structures.

Using these constructs and themes, I built first relationships between them (e.g. a weak orchestrator does not allow direct interaction between the complementors) and went back-and-forth between the literature and emergent theory using multiple iterations (Eisenhardt, 1989; Yin, 2018). I observed that the differences between the identified patterns can be traced back to two surrounding conditions, one referring to the orchestrator and the other to the complementors. As the theoretical frame became clear, I compared it with the literature to sharpen construct definitions. These initial findings pointed towards the information processing literature as an appropriate theoretical lens. Thus, I decided to call the two surrounding conditions “inherent power of the orchestrator” and “required amount of processed information of complementors for realisation of value proposition” (cf. Joseph & Gaba, 2020).

On the basis of these two dimensions, I defined three basic patterns of information processing structures. Then I cross-checked the resulting relations

with the other cases in order to verify their occurrence (Ozcan & Eisenhardt, 2009). I highlighted the respective sentences in the transcripts, added the related codes (1st order concepts) as a comment and transferred the representative quote and its code in a MS Excel file. Sorting the cases by the respective quotes provided a better overview of the 1st order concepts. On this basis I could build 2nd order themes and finally define the aggregate dimensions. Figure 5 illustrates the final coding scheme.

Figure 5: Coding Scheme for Study on Information Processing



In my second study, my analysis of the cases was guided by the four key tasks of orchestration, as described in the literature review: *define value proposition*, *implement value proposition*, *coordinate suppliers and partners*, and *bring new ideas*. As a result, I could observe three distinctly different patterns in the

cases: Single-Orchestration, Double-Orchestration and Multi-Orchestration. These three patterns represent different ways that an orchestrator allocates the key tasks of orchestration. I found that the differences between these patterns are the result of and reflect the orchestrator's knowledge of the production and consumption sides. These inductively found contingencies are also anchored in the literature. A key characteristic of an ecosystem's value proposition is complementarity in both consumption and production (Jacobides et al., 2018). In order to create complementarity in consumption, the orchestrator therefore needs adequate knowledge of potential customers. In this thesis, I call these two contingencies *production related knowledge* and *consumption related knowledge*. The findings and quotes show how these two surrounding contingencies were developed in each case.

In study 3, my cross-case analysis revealed first constructs in a recursive manner (Eisenhardt & Graebner, 2007), representing elements of complementor contributions as well as key aspects of ecosystem governance. I observed that the differences between the identified patterns can be traced back to a company's overall goal associated with the ecosystem. Based on this observation, I was able to define three basic types of complementors. These three types lie on a continuum between minimum and maximum contribution: types A and C represent the extremes, and type B represents a middle way on this continuum. According to the cases, the company's overall goal associated with the ecosystem is the decisive factor and independent variable that determines the contribution and thus the choice of complementor type. When goals changed over time, a single complementor could adjust its contribution and thereby change its type over time. Each adjustment to a complementor's contribution had major consequences for the ecosystem as well as for the other ecosystem actors.

In order to gain a better understanding of these resulting interdependencies in the ecosystems, I studied the inter-firm dynamics more in detail. I then cross-checked the resulting relations with the other cases to verify their occurrence (Ozcan & Eisenhardt, 2009). In the findings section, I show the results of the

data analysis in which I apply the three-layer lens described in the literature review section. Thus, the findings show the three basic types of complementors, the dynamics of type changes that occurred in the case sample and the consequences of a type change for the other actors in the ecosystem.

3.5 Caveat

The following paragraphs provide a caveat that was applied for all studies. It shows that I proceeded with great care in order to mitigate potential methodological biases and closely followed several recommendations from previous works on qualitative research.

In the course of the interviews, I did not reveal any theoretical insights or reasoning to our respondents (G. P. Huber & Power, 1985), and avoided posing questions about specific constructs (Ozcan & Eisenhardt, 2009), which is a way to avoid respondent biases. I consider our respondents to be valid sources of information for several reasons. First, none of the aspects under investigation were particularly sensitive, nor would they damage the reputation or alter the perception of the orchestrator by other companies or persons. Additionally, the anonymisation of the cases reduces the incentive for managers to present their companies in a particularly favourable light. Second, core aspects related to the cooperation were also documented in underlying contracts between orchestrators and complementors. Third, I mainly interviewed executives in charge of managing the ecosystems, i.e. the ones regularly dealing with these core aspects.

In general, I was able to validate the interview partners' core statements with triangulated data and, thus, strengthen their credibility. In addition, I deliberately kept time lags ranging from several weeks up to a few months between the interviews and follow-ups, and withheld transcripts or information from previous interviews from the respondents in between interview rounds. By doing so, I was able to pose questions from previous interviews as part of the follow-ups in order to check the consistency of the answers. In this process, no significant discrepancies between the information provided at different

times were revealed, which also confirmed the credibility of our interview partners.

In order to increase the accuracy of information, I used interview techniques, such as event tracking, to make sure respondents mentally returned to the situations referred to in the questions (Eisenhardt, 1989; Ozcan & Eisenhardt, 2009). Despite the use of semi-structured interviews in the first two interviews per case, I avoided asking very broad questions. I guided the interview partners to provide information that was as specific as possible, and when in case of vague answers, I asked a series of follow-up questions to get more details. Generally, I did not focus exclusively on the questions in the questionnaire, but also asked for additional information around the questionnaire topics. This approach enabled me to put the answers into a wider context and check whether they were consistent with the additional background information provided.

I extensively triangulated the interviews with external as well as internal data (Jick, 1979). In the majority of the cases, key information about the core aspects of the ecosystem was publicly available. For instance, partnerships or cooperation initiatives within the ecosystems were announced publicly, and the joint value propositions were presented in sales brochures or on each firm's homepage. Furthermore, due to the perceived innovativeness of many ecosystem initiatives, there was media coverage of some of the companies' activities, so this generated third party reports. Additionally, I conducted interviews with other companies in the ecosystems or even with third parties.

4 Findings

In this section, I show the empirical findings of my research. These are structured according to the major research foci of my three multi-case studies. Chapter 4.1 illustrates the findings on organizational structures and information processing amongst ecosystem actors. In chapter 4.2, I elaborate on the findings of study 2 about orchestrators. Lastly, chapter 4.3 adds to this understanding by showing the findings about complementors.

4.1 Key Findings on Information Processing

The findings of the first study on organizational structures and information processing amongst ecosystem actors are structured around the three basic patterns of information processing structures, which I briefly mentioned in the section 3.4:

Pattern A: The orchestrator processes and receives the necessary information to orchestrate the ecosystem by the complementors. The flow of information is rather low and the only information that is shared is information that is necessary to jointly run the ecosystem. The complementors are not able to receive information of the other complementors or the orchestrator beyond what is provided by the latter.

Pattern B: Each partner communicates with each other and can process and receive information of the actors within the ecosystem if required or desired.

Pattern C: The orchestrator acts as a bottleneck for information. Instead of allowing direct interaction between the complementors, the orchestrator processes necessary information from one to another. Thus, complementors receive information provided by the orchestrator only.

Within each pattern, I inductively discuss on the basis of the cases how the structure is shaped by the orchestrator, the structure's impact on how

complementors receive and process information, and whether the orchestrator efficient information processing or rather flexible information processing. The data suggested a framework, shown in *Figure 6*, which links the set of patterns to the two surrounding conditions and helps to illustrate the findings. Table VII shows all relevant elements of the framework and provides an overview of the case classification. Table VIII, Table IX and Table X provide the related proof for each case, following the approach of Souitaris, Zerbini, and Liu (2012).

Figure 6: Framework of the three Information Processing Structures

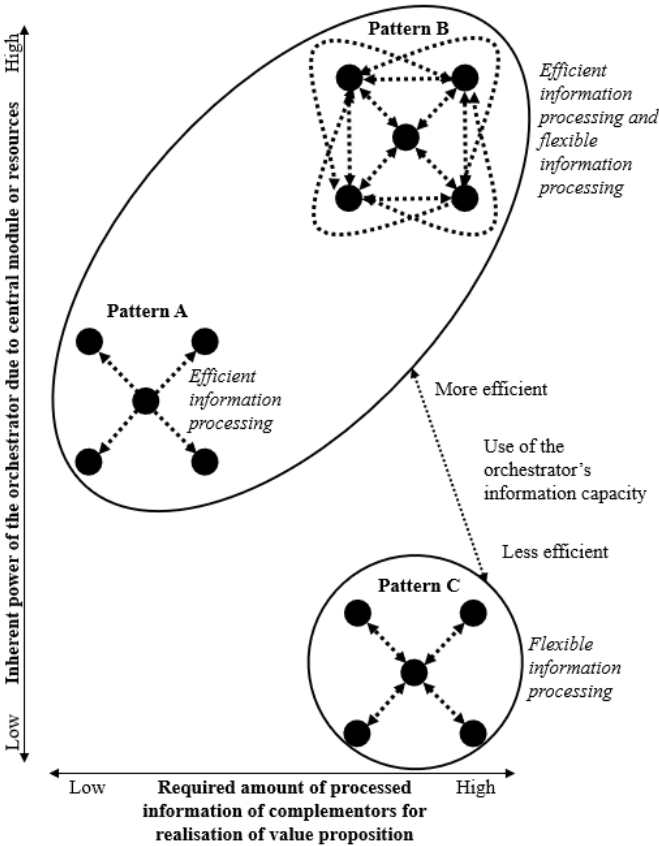


Table VII: Elements of Information Processing Structures

Pattern A		Pattern B		Pattern C	
Inherent power of the orchestrator	<i>Higher</i>	Inherent power of the orchestrator	<i>Higher</i>	Inherent power of the orchestrator	<i>Lower</i>
Information exchange amongst partners	<i>Bilateral information exchange</i>	Information exchange amongst partners	<i>Manifold information exchange</i>	Information exchange amongst partners	<i>Bilateral information exchange</i>
Required amount of processed information of complementors	<i>Lower</i>	Required amount of processed information of complementors	<i>Higher</i>	Required amount of processed information of complementors	<i>Higher</i>
Use of the Orchestrator's information capacity	<i>More Efficient</i>	Use of the Orchestrator's information capacity	<i>More Efficient</i>	Use of the Orchestrator's information capacity	<i>Less Efficient</i>
Timeliness of processing information	<i>Efficient information processing</i>	Timeliness of processing information	<i>Efficient information processing and flexible information processing</i>	Timeliness of processing information	<i>Flexible information processing</i>
Cases	Customized Relocation2 Peer-to-peer Carsharing	Cases	Digital Access Drone Delivery Autonomous Mobility Customized Relocation3	Cases	SME Factoring Customized Relocation1 Review Video Product Insurance

4.1.1 Information Processing Structure of Pattern A

In the Peer-to-peer Carsharing ecosystem, the orchestrator has a strong degree of autonomy when aligning the ecosystem, and only rarely shares information with the other partners and to a lesser extent than in the other information processing structures. The same pattern becomes apparent in the Customized Relocation2 case:

“So, what we're trying to do is actually meet each partner only twice a year. [...] The less communication you have with the partners, the better [...]. R4”

This quote shows that the orchestrator in this case wants communication and interaction with the other actors to be as infrequent and target-oriented as possible. Therefore, in the Customized Relocation2 case, only two FTE (out of 62 in total) were effectively responsible for managing the partners, and both of these employees could mainly use their time for other tasks, such as seeking new opportunities. By only dedicating a small part of the FTE's total time to communicating with the other actors, the orchestrator uses its overall information capacity efficiently (Joseph & Gaba, 2020). This is also true in the Peer-to-peer Carsharing Case, where only two out of 18 employees deal with the tenants and lessors in order to run the ecosystem. Consequently, since the flow of information is rather low and the only information that is shared is information that is necessary to jointly run the ecosystem, this pattern both requires less of the orchestrator's information capacity to be on the other actors, and also leads to the efficient use of the orchestrator's information capacity as well as the complementors' information capacity.

On the downside, complementors are not able to process or receive information of the other complementors, which makes it difficult to share complex or extensive information needed to align different modules or to exchange information on opportunities for the future development of the ecosystem.

“So, of course I try to convey the Big Picture, but logically we get together a few times a year only. They give me a lot of responsibility.” C1

Table VIII: Proof for the Pattern A Cases in Study 1⁷

	Customized Relocation Case Pattern A: Customized Relocation ⁸ (Pattern B: Customized Relocation3) (Pattern C: Customized Relocation1)		Peer-to-peer Carsharing Case Pattern A	
	Classification	Supporting Evidence	Classification	Supporting Evidence
Inherent power of the orchestrator	<i>Higher</i> Moderate Evidence	“If someone would sit down and rebuild our platform, it wouldn’t take him much longer than three quarters of a year to build it the way we built it. But I do not think that is of much use because digital market places [...] are not copiable, but because they have user insights that other platforms or other market players do not have. And that becomes one of our strengths, the user insights, the	<i>Higher</i> Strong Evidence	“Together with car rental companies, we have perhaps ninety percent of the value proposition. And all the others could be replaced.” C1

⁷ In my way of presentation, I followed the approach of Souitaris, Zerbinati, and Liu (2012): Second-order concepts are presented as rows. Within each row, first-order themes are presented in italic as labels for specific data segments. Beneath I present the strength of evidence for each attribute. Strong evidence means that all principal informants explicitly agreed with it repeatedly and indicated an attribute. Moderate evidence means that an attribute was indicated more than once by principal respondents and that the majority of confirming informants explicitly agreed with it. In the Supporting Quotes column, I provide proof quotes from the cases. Occasionally, I offer additional interpretation underneath a quote to explain in more detail how it reflects a concept.

Table V identifies the individuals designated with the letter-number codes.

⁸ The classifications in the column Customized Relocation refers to the Customized Relocation2 Case. For the Customized Relocation1 and Customized Relocation3 Cases I provided a differentiating rationale in the Supporting Evidence column.

		<p>data, the knowledge about the behaviour of the users.” R3</p> <p>Regarding the rare cases of Customized Relocation³, the other actors still receive lucrative leads. These additional revenue sources received by partners from the orchestrator, in addition to their normal business, make the orchestrator attractive to the other actors and ensure a strong position in the ecosystem. Before the implementation of the platform as a start-up in the Customized Relocation¹, the orchestrator had to convince the other partners to cooperate and was a petitioner (i.e. inherently weak).</p>		
Information exchange amongst partners	<p><i>Bilateral information exchange</i></p> <p>Strong Evidence</p>	<p>“We never sit down at the table with more than one partner. [...] Although we compare our reports on the partners internally, we only send them bilaterally to the partners so that they cannot benchmark.” R1</p>	<p><i>Bilateral information exchange</i></p> <p>Strong Evidence</p>	<p>“I had direct contact with the orchestrator, some tenants, the insurance company and the garage, all via the platform” C1</p>
Required amount of processed information of complementors	<p><i>Lower</i></p> <p>Strong Evidence</p>	<p>“What we are trying to do is to meet each partner twice a year. [...] The thing is, the less communication you have with the partners, the better [...]” R4</p> <p>The platform of Customized Relocation² and Customized Relocation³ facilitates the exchange of the partners and makes extensive communication obsolete.</p>	<p><i>Lower</i></p> <p>Strong Evidence</p>	<p>“So, of course I try to convey the Big Picture, but logically we get together a few times a year only. They give me a lot of responsibility.”</p> <p>“If everything works, the whole process runs across the platform. I only have direct contact with the other parties if something goes wrong or there are problems.” C1</p>

		Before the implementation of the platform, the partner's alignment was manual, laborious and required a high spread of the complementor's attention.		
Use of the orchestrator's information capacity	<i>More Efficient</i> Strong Evidence	Two FTE (out of 62 in total) in Customized Relocation ² and Customized Relocation ³ were effectively responsible for the partner's management and both of them could use their time mainly for other tasks such as seeking new opportunities. Without the platform in Customized Relocation ¹ , the majority of the FTE were involved into operational business.	<i>More Efficient</i> Strong Evidence	"There are now 18 employees [...] We actually have two FTEs in customer support, who handle all 100,000 customers." CI
Timeliness of processing information	<i>Efficient information processing</i> Strong Evidence	"Once a month we do have a reporting about the performance of the partners. But we only send it bilaterally [...] So what we are trying to do is actually meet each partner twice a year. [...] So, the thing is, the less communication you have with the partners, the better [...]" R1 Without the platform in Customized Relocation ¹ , the partners needed spontaneous exchange and ad hoc communication.	<i>Efficient information processing</i> Strong Evidence	"We are actually organized in this way, there is a board that is made up of the investors we have, some of whom are also partners in the ecosystem. On average, it meets every two months." CI Apart from the routinized contacts such as damage settlement or invoicing which require little attention, the exchange between the partners is minimized to rare but regular contact points such as yearly meeting with the garages or online contact with the car tenants and lessors every few months.

Accordingly, this pattern of information processing structure is only used for running an ecosystem after the value proposition was in place or for ecosystems with a value proposition that does not require extensive mutual adaptation of modules. For instance, in the Peer-to-peer Carsharing ecosystem, the platform made an information exchange between private lessors and tenants almost obsolete.

"If everything works, the whole process runs across the platform. I only have direct contact with the other parties if something goes wrong or there are problems"

CI

This is also true in the Customized Relocation² case, where the orchestrator bundled all services from the partners regarding the actual move, cleaning, and the transport and sales process for furniture, as well as a free and tailor-made insurance service etc. on its platform, and hardly any information exchange between these individual partners was necessary. Thus, in pattern A cases, the actions of the complementors are rather standardized and require little information exchange between the actors⁹. In other words, the required amount

⁹ With the implementation of a platform, coordination between the key partners has largely been automated in both the Customized Relocation² case and the Peer-to-peer Carsharing case, although they still classify as ecosystems. In this regard, I follow the understanding Jacobides et al. (2018) and their view that multi-sided platforms are not necessarily, in and of themselves, ecosystems, inasmuch as they do not require any nonfungible investment and require only generic supermodular complementarity. Platform hubs, to be able to strengthen their positions, may choose to require some complementors to invest in nonfungible ways. For instance, the way the relocation services are promoted, sold, and provided to the final customer through the Customized Relocation platform becomes unique to that platform, and the same is true for the Peer-to-peer Carsharing platform. These examples are different than other two-sided markets to the extent that providers specialize in the specific interface requirements of the Customized Relocation platform or the Peer-to-peer Carsharing platform, respectively. Thus, the Customized Relocation and Peer-

of processed information of the actors for the realization of the value proposition is low.

Pattern A cases revealed a pre-defined and continuous timeliness of processing information (Joseph & Gaba, 2020). For instance, in the peer-to-peer Carsharing case, apart from the routinized contacts such as damage settlement or invoicing which require little attention, the exchange between the partners is minimized to rare but regular contact points such as yearly meeting with the garages or online contact with the car tenants and lessors every few months

In the Customized Relocation² case, the orchestrator sends out monthly bilateral reports to each partner, meets each of them twice a year, and eliminates spontaneous exchange as much as possible. This information processing structure allows for efficient information processing (Nickerson & Zenger, 2002) and increases the speed and accuracy of decision-makers' perceptions and actions (Ocasio, 1997). Therefore, an orchestrator would manage the orchestration within an information processing structure that allows for efficient information processing, as long as the primary goal is an efficient use of information capacity. On the contrary, a flexible information processing reduces an efficient use of information capacity but broadens the attention of the orchestrator towards the partners' information (Nickerson & Zenger, 2002). If their respective agendas are met, these partners are more likely to be satisfied and accept the position of the orchestrator. Arguably, an orchestrator whose main role is to enable communication within the ecosystem must, of course, be available whenever necessary. As a result, this firm cannot optimize an efficient use of its information capacity if it wants to strengthen its position as orchestrator. Therefore, an orchestrator could be forced to manage the orchestration with information processing structures that allow for flexible information processing if the orchestrator's focus is the maintenance of its position (see Figure 6).

to-peer Carsharing cases each has a multi-sided platform that sustains an ecosystem with the orchestrator at its core.

4.1.2 Information Processing Structure of Pattern B

The case of Autonomous Mobility serves as a good example of a pattern B information processing structure. The five key partners meet regularly in the so-called Comité Opérationnel and openly discuss current or potential future ecosystem initiatives. The partners share all relevant information, as described by the head of the ecosystem initiative:

*“All partners always meet, and everybody knows every partner and everybody exchanges information with every other partner.” **MI***

Likewise, in the Digital Access case, in addition to communication where the orchestrator was involved, the other partners also communicate directly with each other, without the participation of the orchestrator, in order to align their modules. As the Chief Sales Officer states:

*“So, they are communicating bilaterally with each other and have also implemented parts of the value proposition without us being much involved.” **AI***

Another interesting example is Customized Relocation³. In contrast to Customized Relocation², the orchestrator does not run the communication over its platform in cases that are not close to the actual move. Instead, the orchestrator passes the lead to another partner, which directly communicates and interacts with several other partners within the ecosystem. The CEO and founder explains the important difference in the process as follows:

*“And everything else that is not close to the move always runs directly with the partner in his standard process. The partner would now pass on any further suborders directly to other partners.” **R3***

This pattern of information processing structure contains all issues and answers relevant for the ecosystem, which makes it necessary for the partners involved to receive a multitude of different kinds of information. In other words, their required amount of processed information is higher compared to pattern A.

However, since the information does not have to pass through the orchestrator as a bottleneck, the orchestration, per se, requires less of the orchestrator's FTE's time. This is particularly true for the mutual adaptation of complementary modules: Since complementors can exchange information directly, they do not need to involve the orchestrator if their input is not required. In the Autonomous Mobility case, for instance, the partners assign employees to a product development team, which only involves those partners that are necessary for the task at hand. Therefore, in both B- and C-pattern structures, the partners expect to exchange information extensively amongst themselves, whereas the primary purpose of A-pattern structures is the standardized management by the orchestrator. In an information processing structure in which all firms extensively and freely communicate with each other, the orchestrator cannot create a situation in which it withholds information from the ecosystem partners. In addition, since all partners are aware of any information within the ecosystem, as well as possible opportunities for future value propositions, any partner can extend the ecosystem or try to steer it in a specific direction. Thus, the orchestrator needs to have an inherently powerful position within the ecosystem, since otherwise it could easily be replaced or left behind in the case of an extension of the ecosystem.

Table IX: Proof for the Pattern B Cases in Study 1

	Digital Access Case Pattern B		Autonomous Mobility Case Pattern B		Drone Delivery Case Pattern B	
	Classification	Supporting Evidence	Classification	Supporting Evidence	Classification	Supporting Evidence
Inherent power of the orchestrator	<i>Higher</i> Strong Evidence	“By doing the cloud-based locking system and management there, we are relatively firmly anchored in a product that is rolled out” A1	<i>Higher</i> Strong Evidence	The Orchestrator provides necessary financial means and important contacts, but also knowledge and experience particularly with regard to the processes of public transportation	<i>Higher</i> Strong Evidence	“[We] of course, built the whole case [and] provide a certain amount of cross-financing. [...], we can escalate quite well if necessary.” D3
Information exchange amongst partners	<i>Manifold information exchange</i> Strong Evidence	“So, they are communicating bilaterally with each other and have also implemented parts of the value proposition without us being much involved.” A1	<i>Manifold information exchange</i> Strong Evidence	“All partners always meet and everybody knows every partner and everybody thus exchanges information with every other partner.” M1	<i>Manifold information exchange</i> Strong Evidence	“The exchange with the drone technology provider takes place weekly, the exchange with the regulators every few weeks, whenever the drone technology provider cannot get any further there. With the hospital we also exchange every few weeks.” D3
Required amount of processed information of complementors	<i>Higher</i> Strong Evidence	Hardware and software solutions had to be implemented into the car fleet of the car rental company by the other ecosystem partners. For this purpose, the players mutually adapted their modules in order to synchronize the software, hardware and services components	<i>Higher</i> Strong Evidence	Inter-organizational project teams are formed in order to make sure that all partners are involved and can provide their core competencies.	<i>Higher</i> Strong Evidence	In order to execute the delivery of goods via a drone, the drone technology provider has two people on the site at the hospital. The other partners are constantly involved to ensure the technical and regulatory conditions of the ecosystem.

Use of the Orchestrator's information capacity	<p><i>More Efficient</i></p> <p>Strong Evidence</p>	<p>"We have a so-called 'Support Hero' who can also react to spontaneous requests from the customer so that the other employees have as few contact switches as possible." A1</p>	<p><i>More Efficient</i></p> <p>Strong Evidence</p>	<p>"The project managers do not report to the Comité Opérationnel outside the meetings, we keep it as lean as possible. For the past eight months, we have had a communications specialist who has been responsible for coordination and exchange at project level..." M1</p>	<p><i>More Efficient</i></p> <p>Strong Evidence</p>	<p>"One and a half to a maximum of two FTE in our company were partly involved. It was very little for us, because the drone technology provider took over most of it." D3</p>
Timeliness of processing information	<p><i>Efficient information processing</i></p> <p>Strong Evidence</p>	<p>"We have weekly or sometimes daily calls with our technical colleagues that we stay in touch with them. And on the project management side, there are also talks in the range of once a month. We always make sure that this rhythm is kept." A1</p>	<p><i>Efficient information processing and flexible information processing</i></p> <p>Strong Evidence</p>	<p>"Then there's this Comité Opérationnel, all the partners are there. That's five, six times a year or so." M2 It is also possible that project managers or team members do approach decision-makers of the Comité Opérationnel outside these meetings on short notice. This fluidity is also increased by the fact that in some other projects project managers were also members of the Comité Opérationnel.</p>	<p><i>Efficient information processing</i></p> <p>Strong Evidence</p>	<p>"With the drone technology provider, we have [...] a call every week, one hour fixed. Similarly, [the] exchange with the governmental authority [takes place] every few weeks, with the customer too." D3</p>

Accordingly, the orchestrators in the cases of Autonomous Mobility, Drone Delivery, Customized Relocation³, and Digital Access, which all have a higher level of inherent power, apply this B-pattern structure. In the Digital Access case, the power of the orchestrator is a result of its technical expertise and the contribution of its locking system, as the CEO points out:

“By doing the cloud-based locking system and management there, we are relatively firmly anchored in a product that is rolled out.”A1

As for Customized Relocation³, we must consider it in relation to Customized Relocation². The orchestrator’s platform in Customized Relocation² facilitates exchange within the ecosystem for services close to the move (which occur in most cases).

“If someone would sit down and rebuild our platform, it wouldn't take him much longer than three quarters of a year to build it the way we built it. But I do not think that is of much use because digital market places [...] are not copiable, but because they have user insights that other platforms or other market players do not have. And that becomes one of our strengths, the user insights, the data, the knowledge about the behaviour of the users.” R3

In the rarer cases that are not close to the move (i.e. Customized Relocation³), the other actors still receive lucrative leads. Partners receive these additional revenue sources (which are in addition to their normal business) from the orchestrator, whose actions are advantageous to the other actors, which ensures that the orchestrator retains their strong position in the ecosystem. A second source of orchestrator power that we identified in our cases is the orchestrator firm’s indispensability or superiority in terms of resource equipment. For instance, the logistics company does not provide a central module for its ecosystem, but it provides necessary financial funds as well as important contacts to influential people. The Project Manager nicely explains this:

“[We] of course, built the whole case [and] provide a certain amount of cross-financing [...] We can escalate quite well if necessary.” D3

Similarly, in the Autonomous Mobility case, the orchestrator provided financial means and important contacts, but also knowledge and experience, particularly with regard to public transportation processes.

Regarding the timeliness of processing information, we observed a similar logic in pattern-B cases as in pattern-A cases. Whenever possible, the orchestrator sets an information processing structure that allows for efficient information processing in order to optimize an efficient use of information capacity. For instance, in the Drone Delivery case, the orchestrator had a weekly exchange with another actor, as well as regular exchanges with the other partners within the ecosystem:

“The exchange with the drone technology provider takes place weekly, the exchange with the regulators every few weeks, whenever the drone technology provider cannot get any further there. With the hospital, we exchange also every few weeks.” D3

However, it is sometimes necessary to have an additional and spontaneous exchange. Particularly when operational issues occurred, the different actors had more flexible contact via phone, email, or in person. Thus, sometimes they had to be flexible about processing information and were not able to merely rely on a structure that allows for efficient information processing. In our pattern-B cases, we therefore observed information processing structures that allow for both efficient and flexible information processing.

4.1.3 Information Processing Structure of Pattern C

The Customized Relocation¹, Product Insurance, SME Factoring, and Review Video cases serve as good examples of pattern-C structures. In the case of Product Insurance, the orchestrator’s main task was the coordination of an established insurance company and a B2C corporation that produces physical

products. For this purpose, extensive communication is necessary, which in this case runs completely via the orchestrator:

“In the beginning there was someone from the insurer with us. He is still here now, but not so regularly anymore. The last three weeks we certainly had a daily status call with the B2C company” I2

It is similar in the Review Video Case, where the publishers require specific videos and information about how to optimize their video appearance for the end customers, and the community of video and product experts needs instructions and guidance from the video company.

“The communication between the parties runs through us completely anyway [...] The videos always end up with us first and we curate them in a certain way. And then we can match them with our B2B partners“ V1

Thus, the necessary information exchange is high but runs through the video company as a bottleneck. Noticeably, in all the cases of pattern C, the majority of the FTE (SME Factoring, Review Video, Customized Relocation1), or even all (Product Insurance) of the FTE, were involved in the communication with the partners and used a significant portion of their capacity for this task. Overall, all cases of structure C are characterized by a flow of information that is somewhat higher and potentially originates from all the actors. Partners receive some degree of information about the other actors, which is necessary for the realization of the value proposition. Noticeably, this is an important similarity with B-pattern structures, since in both information processing structures the degree of information exchange between the actors has to be high in order to materialize the value proposition. In other words, the required amount of processed information is higher in pattern B and C than in pattern A. However, from an orchestrator's perspective, its role as a bottleneck in structure C means that its use of information capacity is not efficient, since most employees are mainly occupied with the information exchange between complementors.

Table X: Proof for the Pattern C Cases in Study 1

	Product Insurance Case Pattern C		SME Factoring Case Pattern C		Review Video Case Pattern C	
	Classification	Supporting Evidence	Classification	Supporting Evidence	Classification	Supporting Evidence
Inherent Power of the Orchestrator	<p><i>Lower</i></p> <p>Strong Evidence</p>	<p>“The one partner has already wondered out loud why they pay us, because they could do it also by themselves.” I2</p>	<p><i>Lower</i></p> <p>Strong Evidence</p>	<p>“...at the beginning we were much more afraid that they could do this business without us.” F2</p> <p>“...we are in a weaker position than our partners.” F2</p>	<p><i>Lower</i></p> <p>Moderate Evidence</p>	<p>“The shops could take YouTube content as an alternative, but then they would have to request any video to be safe with the rights and we already own the content. We have already requested these rights automatically, so we can easily embed it into any content. We have checked all the content for quality, so many things are important. Video quality, no competition mentions, age, no problematic content, product reviews, length and so on. Then we only include what the shop wants and that is classified so that we only make a few clicks in our database and only the content comes to the shop that fits.” V1</p> <p>Orchestrator provides a beneficial use case but this is still not broadly applied at the shop level. As a start-up, the orchestrator is not fully established and has to prove itself to the shops. Evidence of public reports (archival data) and discussion with FTE from orchestrator and external parties.</p>

Information exchange amongst partners	<i>Bilateral information exchange</i> Strong Evidence	“As an intermediary, we help to mediate between the insurer and the merchant. We are nothing more than a digital broker.” I2	<i>Bilateral information exchange</i> Strong Evidence	“We thought that we would not actually bring people together ... F2	<i>Bilateral information exchange</i> Strong Evidence	“The communication between the parties runs through us completely anyway [...] The videos always end up with us first and we curate them in a certain way. And then we can match them with our B2B partners.” V1
Required amount of processed information of complementors	<i>Higher</i> Strong Evidence	“In the beginning there was someone from the insurer with us. He is still here now, but not so regularly anymore. The last three weeks we certainly had a daily status call with the B2C company.” I2 In order to create the value proposition for a specifically insured physical product, the established insurance company and the B2C company need to extensively exchange information.	<i>Higher</i> Strong Evidence	“We are trying to automate our daily business more and more and to handle it less by email, but we still [...] try to coordinate this as competently as possible with our partners.” F2	<i>Higher</i> Moderate Evidence	“This is one of the plus points that we can offer, that you have a personal contact person with us, that we always answer, are reachable, help and respond to people.” V1 The video producers need to adapt their content to the wishes of the shops; the shops, on the other hand, need to provide input on the content and align their systems towards the specific videos.
Use of the orchestrator’s information capacity	<i>Less Efficient</i> Strong Evidence	“Right now, we have six full-time equivalents. We have been struggling a lot with partner sensitivities over the last few months. Therefore, when I look at where the main energy went, it was certainly not the creation of our platform, but rather the convincing of our partners. Now, depending on the partner, we have to primarily take care of the processing.” I2	<i>Less efficient</i> Strong Evidence	“We put about the same amount of our manpower into day-to-day business and strategic aspects, whereas in the past we spent 80% of our time on strategic matters.” F2 A relatively small team (n = 6) of which 50% is occupied with operational necessities	<i>Less Efficient</i> Strong Evidence	“We are currently five full-time employees and a few freelancers, but they work relatively hard. [...] Communication with partners probably accounts for 70–80 percent of our time.” V1

<p>Timeliness of processing information</p>	<p><i>Flexible information processing</i></p> <p>Strong Evidence</p>	<p>The extensive exchange between the partners required regular contact of short notice. Initially, an FTE of the insurer was also physically present at the orchestrator's premises in order to facilitate flexible communication.</p>	<p><i>Flexible information processing</i></p> <p>Strong Evidence</p>	<p>"It's always been as needed. We have tried to keep regular things as little as possible." F2</p>	<p><i>Flexible information processing</i></p> <p>Strong Evidence</p>	<p>"This is one of the plus points that we can offer, that you have a personal contact person with us, that we always answer, are reachable, help and respond to people. [...] Sometimes we have fifty internal or external meetings a week, external emails. And I am now at about seventy to a hundred emails a day, which I get and write a few dozen to partners myself." VI</p>
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Thus, an orchestrator only uses this information processing structure if it is required to do so, i.e. it has an inherently weak position. For instance, in the Product Insurance case, the orchestrator's position is always precarious vis à vis the other partners. A quote from the COO of the insurance intermediary about the openly expressed thoughts of a key partner illustrates this:

“One partner has already questioned why they pay us, because they could also do it by themselves.” I2

Thus, the orchestrator exerts more effort and prevents a free flow of information regarding the alignment of all modules. In other words, the orchestrator's role as a bottleneck for the exchange of information results in the other partners being unable to see the big picture. This exclusive position regarding the exchange of information within an ecosystem of structure pattern C, ensures some degree of indispensability for the orchestrator. We have observed that the other actors in our cases with pattern-C structures simply do not possess enough information to run the ecosystem without the orchestrator. For instance, FinTech has taken explicit care not to bring the different partners together, as its Head of Marketing states:

“We thought that we would not actually bring people together, because at the beginning we were much more afraid that they could do this business without us. [...] we are in a weaker position than our partners” F2

Consequently, structure C puts the orchestrator into a structurally strong position resulting from its role as an information bottleneck. Therefore, this information processing structure guarantees a powerful position for the orchestrator, but increases its effort to maintain overall communication, which is primarily bilateral between the orchestrator and partners.

Following this logic, we observed that, in terms of communication, the Review Video, Product Insurance and SME Factoring cases had information processing structures that allowed for flexible information processing. This means that meetings, calls, or other forms of local or distant exchange were not predefined in advance but rather occurred spontaneously when required.

For instance, in the Product Insurance case, the orchestrating firm contacted its partners at short notice, according to the COO. In the SME Factoring case, a similar pattern becomes apparent from the description of the Head of Marketing of the orchestrating firm:

“It's always been as needed. We have tried to keep regular things as little as possible.” F2

This information processing structure allows the actors to flexibly attend to information that catches their attention, but it forces the orchestrator to use its information capacity in a less efficient way.

“This is one of the plus points that we can offer, that you have a personal contact person with us, that we always answer, are reachable, help and respond to people. [...] Sometimes we have fifty internal or external meetings a week, external emails. And I am now at about seventy to a hundred emails a day, which I get and write a few dozen to partners myself.” VI

Therefore, it is worthwhile to consider which orchestrator in our cases designed which pattern of information processing structure. The data clearly showed two more efficient structures (pattern A and B) and one less efficient structure (pattern C). Usually, and according to common sense, each firm would use the time of its FTE, most efficiently, if it were in the position to do so. Consistent with our findings, orchestrator firms that choose pattern-B structures have an inherently strong position, which allows for a free flow of information between the actors. On the other hand, orchestrators with a weak position create an information processing structure such as pattern C, which prevents the partners from seeing the big picture and ensure its indispensability as a focal point for relevant information. This observation illuminates an important trade-off from the orchestrator's perspective, between an efficient use of its information capacity and a structural position of power (see Figure 6).

4.2 Key Findings on Orchestrators

The findings of the second study on orchestrators are structured around the three basic patterns of orchestration, which I briefly mentioned in the section 3.4. These three patterns represent different ways that an orchestrator allocates the key tasks of orchestration:

Single-Orchestration: One actor is allocated to the four orchestration tasks. This single-orchestration is possible because one actor has all the necessary consumption related knowledge and production related knowledge to define and implement the value proposition.

Double-Orchestration: One actor is allocated to the strategic tasks, such as defining the value proposition and bringing new ideas. A co-orchestrator is selected for the operational tasks, such as the implementation of the value proposition and the coordination of suppliers and partners.

Multi-Orchestration: Several actors are allocated to all four orchestration tasks. For this allocation, the partners create an inter-organizational project structure with an overarching committee with representatives from all co-orchestrators.

The data suggested a framework that is structured along the four key orchestrator tasks and shows the characteristics of the three basic types of orchestration. This framework serves as the basis for the structure of the findings. I present these findings by describing each pattern structured along the four key orchestrator tasks. The framework in Figure 7 shows all relevant elements of the findings and Table XI provides an overview of the case classification. Table XII, Table XIII and Table XIV provide the related proof for each case.

Figure 7: Framework of the three Orchestration Patterns

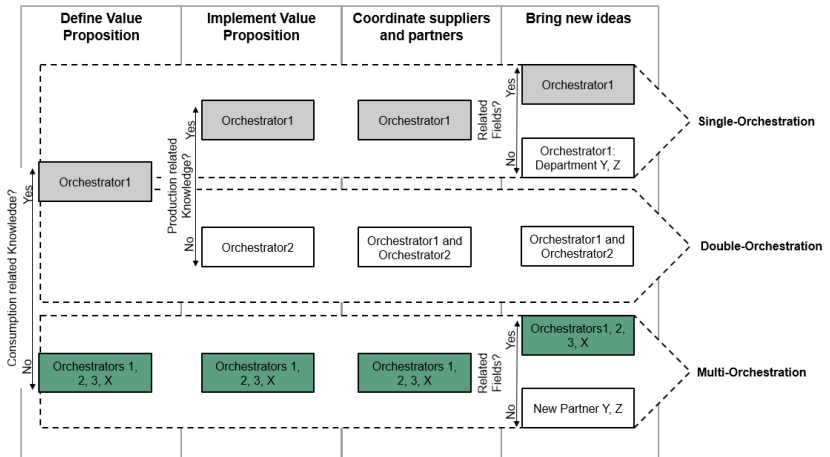


Table XI: Elements of Orchestration Patterns and Case Classification

Single-Orchestration		Double-Orchestration		Multi-Orchestration	
Consumption related knowledge individual orchestrator	<i>Yes</i>	Consumption related knowledge individual orchestrator	<i>Yes</i>	Consumption related knowledge individual orchestrator	<i>No</i>
Production related knowledge individual orchestrator	<i>Yes</i>	Production related knowledge individual orchestrator	<i>No</i>	Production related knowledge individual orchestrator	<i>No</i>
Define value proposition	<i>Orchestrator1</i>	Define value proposition	<i>Orchestrator1</i>	Define value proposition	<i>Orchestrators 1, 2, 3, X</i>
Implement value proposition	<i>Orchestrator1</i>	Implement value proposition	<i>Orchestrator2</i>	Implement value proposition	<i>Orchestrators 1, 2, 3, X</i>
Coordinate suppliers and partners	<i>Orchestrator1</i>	Coordinate suppliers and partners	<i>Orchestrator1 and Orchestrator2</i>	Coordinate suppliers and partners	<i>Orchestrators 1, 2, 3, X</i>
Bring new ideas	<i>Orchestrator1</i>	Bring new ideas	<i>Orchestrator1 and Orchestrator2</i>	Bring new ideas	<i>Orchestrators 1, 2, 3, X</i>
Development of value proposition	<i>Related or unrelated Fields</i>	Development of value proposition	<i>Unrelated Fields</i>	Development of value proposition	<i>Unrelated Fields</i>
Cases	Digital Access SME Factoring Customized Relocation	Cases	Drone Delivery	Cases	Autonomous Mobility Connectivity Services Connected City

Table XII: Proof for the Single-Orchestration Cases in Study 2

	Digital Access Case		SME Factoring Case		Customized Relocation Case	
	Classification	Supporting Quotes	Classification	Supporting Quotes	Classification	Supporting Quotes
Consumption related knowledge individual orchestrator	Yes Strong Evidence	“We have had discussions with the customers to validate that this idea basically has market potential. And then we brought in partners.” A1 “We have done market research. We have spoken to trade fairs; we have also spoken to hotels. And we looked at how we could best position ourselves in the market.” A1	Yes Strong Evidence	“And I must also say, I don't know if we talked about it, we were aware of the problem right from the start.” F1 “In this respect, we believe that there is a nice target market for us that tends to grow. These are the SMEs, which do not have any bad turnaround stories or the like, but are simply not in such a good phase of their lives or are generally a bit weak on the equity side, which simply get less and less credit from their house banks and are being driven more and more into our clutches.” F1	Yes Strong Evidence	“We have seen that the problem is that in Switzerland the moving market is extremely untransparent [...]. There are two or three okay big brands, but no dominant brands. Then we saw, okay, on the one hand there is room for a brand that can identify with the issue of relocation for the client in the long term. And above all we saw, hey there is a customer need for a certain security and comparability in the market. And from this we developed the product.” R3 “The estimate now is that there are 480,000 households and about 100,000 of them use a moving company and another 50-100,000 use a cleaning company. So, our direct moving market is 200,000 users plus minus.” R3
Production related knowledge individual orchestrator	Yes Strong Evidence	“I'd say yes, definitely. So, some of our partners do not have a great competence or at least not as deep a competence as we do, especially in the area of virtual reality and we can	Yes Strong Evidence	“Innovation is actually in the role of coach or club manager, we say we bring the best specialists together, who would never have thought of playing together, but we	Yes Strong Evidence	“So internally, it's certainly the digital understanding and tech know-how that we have. We see ourselves as a tech company, over 60 percent of our employees are IT specialists.” R3

		<p>already add value to them.” <i>AI</i> “We are the ones who bring technological components together to make the whole system work.” <i>AI</i></p>		<p>have realized that they all have special skills and they all work together very well. And that's where the technical platform really is a player and we're now considering replacing part of that technical platform player with someone else who's a bit stronger in the role.” F1</p>		<p>“It's all self-programmed in that sense. And it is an open source technology, we have built this by ourselves. Yes, standard technology in that sense. What was built is of course then our own creation.” R2</p>
Define value proposition	<i>Orchestrator!</i> Strong Evidence	<p>“We started with the vision that the smartphone becomes key. That hasn't changed from day one to today.” A1 “So mobile key is still the same core element. But the value proposition to the customer that we put into the business model was already more than we had in the core at that point. In essence it's mobile key. And then we just added, here, you have a frontend here, you can authorize your friends here, etcetera. All added value, which we actually depict via our system integrators or partners.” A1</p>	<i>Orchestrator!</i> Strong Evidence	<p>“You can say that there was a customer need in the beginning. The goal was to offer a clever factoring solution. Not too complex, a low-cost solution. The original idea was a slightly different structure, where the parties involved were quite similar, but in terms of who insures what, who does what, it would be different. In interaction with the partners and what is possible, this solution has developed.” F1 “Very much from the Pain Points of our customers, [...]and then from there we developed our value proposition [...] In this respect it can be clearly said that the value</p>	<i>Orchestrator!</i> Strong Evidence	<p>“In this sense it is a moving portal. What we offer our customers is a contact point that solves everything around the topic of moving from one source.” R3 “A very central point of the whole thing is that we have Move Captains, our client advisors, who independently guide the client through the whole process and help in case of difficulties, which is of course an advantage compared to just dealing with the company and if you have difficulties, you have no one who can help you.” R3</p>

				proposition came from us.” F1		
Implement value proposition	<i>Orchestrator1</i> Strong Evidence	“In the beginning was the idea. Then we built a prototype. And then we spoke directly to the customers.” A1	<i>Orchestrator1</i> Strong Evidence	“From the very beginning, we knew what our customers were doing and what they were missing. From there, we developed our value proposition. [...] In this respect, you can clearly say that we developed the value proposition entirely by ourselves.” F1	<i>Orchestrator1</i> Strong Evidence	“So [relocator] guides the customer through the whole process until the day the moving company is in the house. And [relocator] is also responsible for the billing and everything else, including satisfaction. [relocator] is not a platform that simply mediates and is the contact person for the entire process.” R2
Coordinate suppliers and partners	<i>Orchestrator1</i> Strong Evidence	“In the project phase it is actually the case that you have to communicate at least once a month.” A1 “And later, when we said that we needed our own frontend, we tried to orchestrate it with several partners. We got that under control to a certain extent by splitting up these roles that we had planned. Namely, on the one hand, one talks to the partner, that is one thing. He is always reactive and reacts when he has time. And on the other hand, we have restructured the whole subject of support in such a way that we have a so-called Support Hero who is currently in charge of support and performs this	<i>Orchestrator1</i> Strong Evidence	“We manage the ecosystem strongly above us, and we want that too. We want to try to sit like a spider in a web and keep the interactions of others to a minimum [...] We are the bottleneck in each other’s interactions, the puppet coordinator so to say.” F1 “The coordination effort for us is relatively high, but it also gives us control.” F1 “Partner management was certainly over fifty percent. [...] because the basic value proposition, where loans are given out, was clear from the beginning and we didn’t do much more fine-tuning, and then the	<i>Orchestrator1</i> Strong Evidence	“So currently it is already the case that a lot of coordination runs through [relocator]. So even what happens later with the add-on partners is actually only handled by [relocator].” R2 “Although we compare our reports on the partners internally, we only send them bilaterally to the partners so that they cannot benchmark.” R4 “So, what we try to do is to meet each partner twice a year, just to say yes, or at least to make a phone call. That’s what we want to do in the future.” R1

		role accordingly. And he can also be contacted by the customer in response to spontaneous inquiries.” A1		fossilization of the value proposition was actually more a result of us having to work together with the partner, and from that the end product came out a bit.” F1 “We coordinate over short distances and have 2-3 contact persons everywhere. [...] You sit and call one after the other individually with short telephone calls. [...] For each partner we have one who is on site and who we know well.” F1		
Bring new ideas	<i>Orchestrator/1</i> Strong Evidence	“The same people are responsible for the operational communication with the partner as for the strategic communication.” A1	<i>Orchestrator/1</i> Strong Evidence	“I think it is important for us to always have our finger on the pulse, even when it comes to innovation within the ecosystem and the further development of the ecosystem, it is almost always driven by us. It is very, very rare that we actually have to react to changes from partners.” F1 “We are a young company and without our drive the ecosystem would probably dry up relatively quickly or at least not continue as we imagine it to be. Because we are a young company,	<i>Orchestrator/1</i> Strong Evidence	“When I joined, [...] I started to write lists, what could the customer need, what is he interested in when he moves. And that's just how we expanded it, we just thought about it, well, what other topics are interesting?” R4

				we need constant innovation to move forward.” F1		
Development of value proposition	<i>Related Fields</i> Strong Evidence	“Our growth strategy is [...] to develop further in the value chain rather than in the value proposition.” A1 “I would say that this is a product that is being developed step by step, or that will at some point be integrated into a larger product world, i.e. integrated at the manufacturer, the OEM.” A1	<i>Related Fields</i> Strong Evidence	“The value proposition, per se, stands. The exact value proposition is adjusted slightly on an ongoing basis, but at most in the single-digit percentage range.” F1	<i>Unrelated Fields</i> Strong Evidence	“The link between us and the removal and cleaning companies is clearly the core of the service. From the beginning, we also had the axis with the business development partners in mind, but this is enormously complicated for the fact that it might bring 10-15 percent for the business.” R4 “And the goal was of course to grow in the core business and to test what is possible in the other fields.” R2

Table XIII: Proof for the Double-Orchestration Case in Study 2

	Drone Delivery Case	
	Classification	Supporting Quotes
Consumption related knowledge individual orchestrator	<i>Yes</i> Strong Evidence	“We simply had what was certain to be our strength in Switzerland, we know the market, we know the local conditions and we have contact with the customers.” D2 “We also had an initial understanding of the case, but, of course, the idea about the case grew out of dozens of conversations with various customers. Our strength in Switzerland was our market knowledge. We know the local conditions, and we have the contact with potential customers.” D1
Production related knowledge individual orchestrator	<i>No</i> Strong Evidence	“At the start we did not have much knowledge about drones compared to the knowledge we have today.” D1 “I think we have learned a great deal in the first three to six months, especially in the area of aviation.” D1
Define value proposition	<i>Orchestrator1</i> Strong Evidence	“We first looked for a value proposition and then tried to get partners [...] And then you had the partners. Then you brought the partners together and then you finally developed the product and thought about what we could deliver with it and then someone recognized that hospitals can be interesting.” D2 “[Logistics company] was very much in developing the viability of the delivery of the solution. [Drone technology provider] has been really the strong suit in terms of technology.” D6 “It was definitely beneficial to have a partner like [logistics company]. A partner like this is able to translate a technology into an actual application as the technology alone does not create value [...] hence they were able to translate the technology into a solution.” D6
Implement value proposition	<i>Orchestrator2</i> Strong Evidence	“The drone technology provider has spent most of the resources or time. I would say the contribution is probably about 50 percent of the drone technology provider. [...] our role is more that of an enabler.” D1 “The [drone technology provider] who develop the drones, who create the stations. They basically create that.” D2 “[Logistics company] was very much involved in developing the viability of the delivery of the solution. [Drone technology provider] has been really the strong suit in terms of technology.” D6 “The drone technology provider has two people on site, who monitor the whole thing all the time and [cooperate], its mainly operational.” D3
Coordinate suppliers and partners	<i>Orchestrator1 and Orchestrator2</i> Strong Evidence	“Since our management knows the people at the [regulator], we can escalate quite well if necessary. [...] we have escalated once or twice when our CEO directly went to the head of [regulator].” D2 “[drone technology provider] and the hospital work closely together on an operational level so they communicate daily. [...] but this will not be necessary anymore once the process is automated. [...] [drone technology provider] and [regulator] also communicate operatively. We are the enablers so to say.” D1

		“Strategic topics are generally discussed every half a year or year on a physical level, but only with [drone technology provider]. [...] customers are not to be involved in strategic questions.” D1
Bring new ideas	<i>Orchestrator1 and Orchestrator2</i> Strong Evidence	“Bringing in new ideas is more like a collective – not one actor who is pushing alone for the new ideas.” D4
Development of value proposition	<i>Unrelated Fields</i> Strong Evidence	“In transportation, drone transportation already existed. But it wasn’t really commercialised and generalised. There were always big discussions about the potential of drones in logistics.” D1 “For us and [logistics company] it is a new territory and it is something that is constantly evolving, and I think leading to a strengthening of the ties between the three parties involved.” D4

Table XIV: Proof for the Multi-Orchestration Cases in Study 2

	Autonomous Mobility Case		Connectivity Services		Connected City	
	Classification	Supporting Quotes	Classification	Supporting Quotes	Classification	Supporting Quotes
Consumption related knowledge individual orchestrator	No Strong Evidence	<p>“And we can also provide important access to real customers. I think when it comes to testing something with our passengers from [logistics company]’s bus or our customers and so on that’s, well, that’s basically what we bring.” M1</p> <p>“And with such a large company like the [logistics company], I think it is justified that they say that you can see where the needs are and where the market is developing, something a university cannot do and what the public sector cannot really do.” M2</p>	No Strong Evidence	<p>“And we test it all and collect feedback directly from the farmers who are in our innovation pool. And so, we’ve actually covered everything from us to the customer, and we collect the appropriate feedback everywhere [from our partners], the know-how, make the product complete and then go to market.” AG1</p>	No Strong Evidence	<p>“Two years ago, we didn’t have a network at all, but now we are in active contact with several cities, municipalities, city representatives, other (...) political bodies on the subject and so on.” B1</p> <p>“This is all very unclear, and it is a huge challenge. So, we are trying to get a little bit of certainty in here by validating the individual business cases that we build with the potential customers. We have, for example, carried out a mobility assessment within the city of Zug, and we are now planning to talk to surrounding companies and ask them whether the concepts would fly as we had thought if they were part of it. It is an incredibly big challenge to assess this.” B1</p>
Production related knowledge individual orchestrator	No Strong Evidence	<p>“The field and also the know-how must also be developed, not only with us, but they must also develop certain know-how themselves. This is a process. It is not that the information is available</p>	No Strong Evidence	<p>“These are actually very different competences that are in demand. So, from data analyst, from remote sensing expert, biological, economic knowledge.” AG2</p> <p>“We have research, which gives us new basic knowledge for the use cases, which we need (...)”</p>	No Strong Evidence	<p>“This means that we do have this knowledge within the company, although, as I said, our core competence is more limited to the history of the automotive industry and the history of mobility and related topics, and on the other hand</p>

		<p>somewhere, it has to be found accordingly.” M1</p> <p>“We did not want to be just a public transport provider anymore; we wanted to be a multimodal integrated mobility provider. That was the vision. And we’ve already identified a few challenges on the way to the vision, and then we said we couldn’t achieve that alone. Disruptive topics such as autonomous driving cannot be tackled by us alone. That’s why it’s important that we find the relevant partners to deal with. And then we activated our network.” M2</p>		<p>they provide the basic know-how somewhere (...) and then you have the partners who provide the connectivity.” AG1</p>		<p>[Software Company] of course has similar knowledge. This means that we also find a high level of core competence there in terms of smart cities, in the IT and software sector.” B1</p> <p>“There would have been far too much knowledge missing.” B1</p>
Define value proposition	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“First we got the partners and then started looking for a value proposition.” (TG)</p> <p>“The important decisions are made in this Comité Opérationnel. [...] There are people who do not understand the project level in detail, but who probably have a greater overview in their organization and can use strategically better synergies.”</p>	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“Everyone has the same goal, so the value proposition shows the same relevance for all parties involved.” S1</p>	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“We have only just reached the point where we [use] Multi-Orchestrator. Actually, the cooperation has now been consolidated. There is a [Software Company] in there, there is a [consulting firm] in there. And we are in close contact with the city administration and with local companies.” B1</p>
Implement value proposition	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“And then each partner put their core competence on the table to advance the topic of autonomous driving.” M2</p>	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“There are data service providers, I would call them, who do something with agricultural, be it machines, but also sensors from the field. There are sensor</p>	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“For this reason, we have joined forces with [Software Company] as a technology provider, a technology partner, who should actually also take</p>

		<p>“This actually means that when a project is made, a group is formed. [...] At this project level, it is a matter of operational exchange.” MI</p>		<p>manufacturers, sensor platform manufacturers, i.e. people who operate drones, who operate the sensor technology and there are machine manufacturers. [...] Both farmers and machine manufacturers are, in principle, end users of this data exchange platform, because the agricultural machines also want data, or the agricultural machine manufacturers want to evaluate data from external sensors.” S1</p> <p>“The machine manufacturers bring the data into the platform (...) This is actually about bringing it together and simplifying it (...) and then there are the research partners.” AG2</p>		<p>over its role in the daily area, and we have also joined forces with [consulting firm], a consulting pool, who has a good network in the corporate and urban environment groups and with a certain neutrality.” B1</p>
<p>Coordinate suppliers and partners</p>	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“There are usually also some members of the Comité Opérationnelle who are responsible for or affected by these projects as project managers. They then observe what happens in the project and exchange information accordingly.” M2</p> <p>“This actually means that when a project is made, a group is formed. [...] At this project level, it is a matter of operational exchange.” MI</p> <p>“Regarding the coordination of partners, there was a meeting each week or every three weeks where we talked</p>	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“The coordination is mainly done by us and partly by [the Research Institute].” AG1</p> <p>“I am the coordinator of the project, we also have work packages [...], also these picture scans about the vineyard. And in the architecture, the software architecture of the overall system. And that's mainly the [CEO of the Agricultural data company]'s responsibility, he's the work package manager, and he's responsible for the software architecture.” S1</p> <p>“There are a few, I mean with thirty partners, you always have a few key players with you.” S1</p>	<p><i>Orchestrators 1, 2, 3, X</i> Strong Evidence</p>	<p>“We have a good connection to [the train company]. On the other hand, [Software Company] has a strong network because they are already represented in all communities and so on.” B1</p> <p>“We have also distributed tasks, the governance model, for example what to take to integrate additional partners and how to build that up and who to build up the financing model and so on.” B1</p>

		about the timeline. All in all, frequent meetings, contacts, E-mails. [...] In the city there was a working space, but the meetings often took place in the Comité Opérationnelle working space.” M2		“We said that we didn't want to do it ourselves, so [the Research Institute] is the lead and we are more of a co-lead.” AG1		
Bring new ideas	<i>Orchestrators 1, 2, 3, X</i> Strong Evidence	“There are practically three levels where new ideas can emerge, i.e. new applications, firstly by saying, for example, that [logistics company]-internally, that the [logistics company] itself brings ideas, then ecosystem-internally, [and third] that you say you have an opportunity here and that you bring in third parties for creation workshops.” M1	<i>Orchestrators 1, 2, 3, X</i> Strong Evidence	All project partners can bring new ideas that are related to the project.	<i>Orchestrators 1, 2, 3, X</i> Strong Evidence	All project partners can bring new ideas that are related to the project.
Development of value proposition	<i>Related Fields</i> Moderate Evidence	“Ideas for projects come from the circle of members of the Comité Opérationnelle or from creation workshops where the members invite external persons from their business network.” M1	<i>Related Fields</i> Strong Evidence	“So we have an idea here, what you could implement, and then you check it out with them, sometimes first mocks and asks how that could work and then you make clickthrough prototypes, and then it's up to them to use that, that you also get feedback from them: Is it going well? Is it going badly? What do you have to improve?” AG1	<i>Related Fields</i> Strong Evidence	“We have these five sub-projects where we have to build up individual value propositions. And we have actually planned a very distinct sounding board between these sub-projects, so that they can constantly exchange ideas with the hope that, on the one hand, you can recognize the potential of how to combine the individual projects and thus create new products in co-creation.” B1

4.2.1 Define Value Proposition

The first key task facing orchestrators is to define a new customer value proposition. In four of the seven ecosystems (Digital Access, SME Factoring, Customized Relocation, Drone Delivery), a single orchestrator defined the value proposition. One interviewee justified this as follows:

“We simply had what was certain to be our strength in Switzerland, we know the market, we know the local conditions and we have contact with the customers.”

D2

This is a nice illustration of how an individual orchestrator must have adequate knowledge of potential customers to define the value proposition on its own. The need to have consumption related knowledge (see chapter 3.4) was also evident in the analysis of the other case studies. For instance, in the Drone Delivery case, consumption related knowledge was described as an important core competence necessary for the orchestrator to define the value proposition. Regarding the building of an ecosystem using the single-orchestrator approach, the case analysis showed that an ecosystem is built by a partner developing a use case and then finding the necessary partners, as well as the clients. In addition, another interviewee described how they developed the value proposition themselves based on the identified needs of the customers:

“Very much from the Pain Points of our customers, [...]and then from there we developed our value proposition [...] In this respect it can be clearly said that the value proposition came from us.” F1

When looking at the three other cases (Autonomous Mobility, Connected City, and Connectivity Services), more than one player was involved in this task of defining a value proposition. It appears that in the absence of consumption related knowledge of an individual actor, a multi-orchestrator approach was used to define a value proposition. This is because only by working together could the partners retrieve enough consumption related knowledge to define a

value proposition. One exemplary interviewee explains this necessary collaboration as follows:

“There would have been far too much knowledge missing and from the network point of view there would have been too much missing (...)” B1

In order to be able to cooperate effectively, the co-orchestrators in both the Autonomous Mobility and Connected City cases formed an overarching committee. In this committee the partners collaboratively developed a use case and defined the value proposition. Therefore, to summarize, consumption related knowledge is the key contingency in the cases regarding the task *define value proposition*. If a single partner had enough consumption related knowledge, it was able to define the value proposition on its own and therefore followed a single-orchestrator approach. However, if one partner did not have enough consumption related knowledge to define the value proposition, it involved additional partners as co-orchestrators.

4.2.2 Implement Value Proposition

The cases revealed three different approaches to implementing the value proposition. In the first approach, an orchestrator implements the value proposition on its own. In the second approach, the initial orchestrator integrates another co-orchestrator and delegates the implementation role to this partner, as in the Drone Delivery case. The third possible approach involves multiple co-orchestrators. These create a project structure beneath the overarching committee in which a project manager in an inter-organizational project team is responsible for implementing the value proposition.

The implementation of the value proposition demands production related knowledge, which appeared to be the decisive factor determining the allocation of this orchestrator task in the cases I analyzed. I call this knowledge *production related knowledge* (Jacobides et al., 2018). In the first approach to implementation, the firm posits all production related knowledge necessary to implement the value proposition. In these cases (e.g. SME Factoring, Digital

Access, Customized Relocation, Disease Detection, and Connectivity Services), a single orchestrator steers the development of technical components. For instance, the orchestrator of the Digital Access case was able to contribute the technical know-how from its experience as a tech company. Hence, it could establish a functional system by bringing together the technological components that provided the basis to implement the value proposition. As the CEO in the Digital Access case put it:

“Some of our partners do not have a great competence or at least not as deep a competence as we do, especially in the area of virtual reality.” AI

In the second pattern of orchestration (as described above), the initial co-orchestrator lacks profound production related knowledge and therefore delegates the implementation role to a co-orchestrator. Thus, the logistics company developed the use case but then a drone technology provider was selected to implement the drone delivery system on site. Once the ecosystem was established, the logistics company made the drone technology provider responsible for the day-to-day business and communication with the client. As the Head of Autonomous Delivery explained:

“The drone technology provider has spent most of the resources or time. I would say the contribution is probably about 50 percent of the drone technology provider. [...] our role is more that of an enabler.” D1

The multi-orchestrator ecosystem cases (e.g. Connectivity Services, Autonomous Mobility, and Connected City) revealed that the co-orchestrators had to develop production related knowledge by working in close coordination. Implementation of the value proposition required the respective core competencies and know-how of all the partners, as described by the Head of the Project Lab:

“The know-how must also be developed, not only with us, but they must also develop some know-how themselves. This is a process.” M2

4.2.3 Coordinate Suppliers and Partners

The third key task of orchestrators is the coordination of suppliers and partners in the ecosystem. This is particularly relevant for an ecosystem, since there are strong interdependencies between the partners and these are not managed in a fully hierarchical manner (Jacobides et al., 2018). Thus, the orchestrator needs to understand the agendas of the other actors and steer the operational activities in the ecosystem.

In the single-orchestration ecosystems (e.g. Digital Access, SME Factoring, Customized Relocation), a single actor was responsible for this coordination. In these three cases, this exclusivity was a deliberate choice in order to maintain control over the ecosystem and all the partners. The Head of Sales & Marketing in the SME Factoring case explains this strategy as follows:

“We manage the ecosystem [...]. We want to try to sit like a spider in a web and keep the interactions of others to a minimum [...] We are the bottleneck in each other’s interactions, the puppet coordinator, so to say.”

F1

In the Drone Delivery case, I observed an interesting sharing of this role between the drone technology provider and the logistics company. Since the drone technology provider is responsible for the day-to-day business, this firm mainly steers the operational activities within the ecosystem and communicates with the partners in this way. However, when difficulties occur, the transportation company intervenes on behalf of the drone technology provider and facilitates exchange when necessary. D2 explains that the two companies share this coordination role because the management at the transportation company has a more extensive network of contacts, in particular at the regulator, than the executives at the other partner firms.

“Since our management knows the people at the [regulator], we can escalate quite well if necessary. [...] we have escalated once or twice when our CEO directly went to the head of [regulator].” **D2**

A similar strategy becomes apparent in the multi-orchestrator ecosystems (e.g. Connectivity Services, Autonomous Mobility, and Connected City). In these cases, the project leader steers the partners in the inter-organizational project team. If necessary, the project leader brings problems to the attention of the overarching committee. The partners wanted a close exchange between the two levels of the operational project and the strategic committee, as well as between the different actors involved. Thus, some employees who are responsible for or affected by these projects are also members of this committee and exchange information accordingly.

4.2.4 Bring new Ideas

The last major orchestration task is the introduction of new ideas to the existing ecosystem. These ideas refer to further developing or expanding the ecosystem's existing value proposition. In this regard, I observed two basic patterns in the cases. In the first pattern (i.e. SME Factoring, Digital Access), the actors who brought in new ideas were the ones who were mainly responsible for the implementation of the value proposition and the coordination of the partners. This means that these people were mainly occupied with operational tasks and acquired knowledge in this area. The intended result was that the value proposition developed was path-dependent and in fields related to their existing business in which the partner had prior knowledge.

“Our growth strategy is [...] to develop further in the value chain rather than in the value proposition.” AI

In the second pattern of orchestration, new ideas deliberately came from actors who were not involved in the day-to-day business. An excellent example is the Customized Relocation case. After creating the platform and implementing the first value proposition, the founder and CEO deliberately created a new and independent business development department. When the Head of Business Development joined, he was capable of exploring new opportunities for the business without being pre-occupied by the operational necessities:

“When I joined, [...] I started to write lists, what might the customer need, what is he interested in when he moves. And that's just how we expanded it, we just thought about, well, what other topics are interesting?”

R4

As a result, the orchestrator was able to broaden its perspective into previously unrelated fields. This led to the integration of entirely different modules beyond the core service of the move and expanded the value proposition with new aspects, such as partnerships with furniture stores and insurance companies. Therefore, if the orchestrator intends to develop the value proposition beyond path-dependency in related fields, it needs input from people outside of the operational core business. The multi-orchestrators in the cases Autonomous Mobility, Connected City, and Connectivity Services were also aware of this connection and created opportunities for external ideas. This is nicely explained by M2:

“There are three levels where new ideas can emerge. [...] First, [...] the post itself brings ideas, [second] ecosystem-internally, [third] that you bring in third parties for creation workshops.” M2

4.3 Key Findings on Complementors

This section is structured around the three-layer lens described in the literature review section. First, I describe the three different types of complementors found in the cases. Second, I illuminate the dynamics of these individual complementors and the type changes that occurred in the case sample. Lastly, I describe the consequences of a type change for the other actors in the ecosystem.

4.3.1 Three Types of Complementors

In an initial step, I introduce the three basic complementor types. For each type, I discuss the complementors as the unit of analysis, focusing on their contributions to the ecosystem and their links to the other actors.

Type (A): The complementor's primary goal is access to innovation opportunities and its module consists primarily of know-how and barely any operational resources.

Type (B): The complementor's primary goal is a specific value proposition to incrementally improve its own offerings and its module consists of know-how and limited additional operational resources.

Type (C): The complementor's primary goal is a specific value proposition that is essential to the firm and its module consists of know-how and a significant portion of its operational resources.

Table XV provides an overview of this typology of complementors. Table XVI, Table XVII and Table XVIII provide the related proof for each firm.

Table XV: Overview Complementor Types

	Type A	Type B	Type C
Objective of complementor	Gain access to innovation opportunities and partner network . The Value Proposition is solely a means to an end .	Realization of a specific Value Proposition that incrementally improves existing offerings	Realization of a specific Value Proposition that is essential to the firm
Contribution level of complementor	Lower	Medium	Higher
Contribution specifics of complementor	Minimal provision of operational manpower and additional resources	Limited provision of operational manpower and additional resources	Significant provision of operational manpower and additional resources
Internal organization of complementor	Decision-making authority within middle management	Decision-making authority within middle management	Decision-making authority within a small, agile, and autonomous project team
Governance of complementor	<ul style="list-style-type: none"> ➤ The orchestrator needs regular access to decision-makers to permanently offer advantages that go beyond the ecosystem ➤ The operational exchange is limited due to the low commitment of the complementor 	<ul style="list-style-type: none"> ➤ The orchestrator needs regular access to decision-makers to permanently demonstrate the added value of the specific value proposition ➤ The operational exchange is regular and frequent 	<ul style="list-style-type: none"> ➤ The orchestrator and the complementor are on equal footing due to existing equivalent mutual dependence on the specific ecosystem ➤ The operational exchange is regular and frequent

4.3.1.1 Type A

Actors

In the three cases, type A complementors became engaged in the ecosystem with an approximate idea, but no exact specification, of their ultimate reward for being part of the ecosystem. In the cases, this was initially true for two complementors: *vineyards* and *machine manufacturer 2*. Both were particularly interested in the innovation opportunities that arose from

digitization, which was not part of their core competencies. For *machine manufacturer 2*, the core competence are clearly machines but not data analysis:

“What was interesting for us [...] was the know-how in the processing of images, satellite images, soil data and algorithmic knowledge.” S3

In the cases, the benefit to this type of complementor stems, to a lesser extent, from the concrete value proposition. Rather, the goal is to benefit from innovations or to maintain the possibility of further potential partnerships. In this context, the complementors regard the value proposition more as a means to an end to achieve these overriding objectives. This specific value proposition is therefore not crucial to the existence of the complementor. The CEO of the *vineyards* nicely explains this goal:

“I was more interested in estimating how high something like this could get, where could it end, is it feasible? But clearly, this project does not provide for the basic existence of our winery.” H1

Similarly, *machine manufacturer 2* realized that digital services in the agronomic industry are becoming more important and that the firm must learn from digital opportunities. As a leading machine producer in the agricultural industry, *machine manufacturer 2* regarded the opportunities arising from the connectivity project as a nice-to-have rather than a must-do. The operative core business of machine manufacturing remained the clear focus, which is nicely explained by S3:

“The operational core business simply has a higher priority. Someone buys a machine and you must make sure it keeps working. And with digitization, our customers still have little added value.” S3

The internal organization of the complementor reflects the low priority the ecosystem has for these complementors. At *machine manufacturer 2*, the decision-maker responsible for cooperation with the *agriculture data company*

is the head of the electronic market department, which has 70 employees. He must deal with numerous topics (around 100 projects simultaneously). Therefore, he can hardly provide sufficient operational capacities for cooperation. If a new project is initiated, it must be conducted by a local project team, and the local R&D team needs to provide additional resources. A he explained:

“If a new project is started, we discuss whether we will do the project, how we do it, where it will take place. And then everyone who is involved says ‘yes, we can do it, I have the resources, or I don’t have them’.” S3

At *vineyards*, the internal organization is different. A well-known Swiss entrepreneur’s foundation provides strong financial backing. The head of this foundation has a significant influence on the release of financial resources. In this way, the manager also decides whether to engage in possible projects or cooperations that would require additional resources. In addition to the foundation, there is the CEO of the wineries who is a specialized oenologist, who is responsible for all operational activities related to the vineyards. These two people coordinate closely and work by consensus, with the manager of the foundation having more influence on the strategic aspects of the winery and the CEO having more influence on the operational aspects. This setting means that *vineyards* is more likely to provide financial funds for projects rather than significant operational resources from the winery. Since the type A complementor lacks operational resources, its focus is on minimizing its own workload. This basic premise means that type A is a potentially fragile partner within the ecosystem (see dynamics section).

Contribution

Due to these internal limitations, the complementors contributed at a relatively low level. Specifically, these types primarily contributed a module of specific know-how with clearly limited operational capacities to the cases. For instance, the complementor *vineyards* had several employees of other partners evaluate the data physically in parallel with the digital analysis:

“There was [employee of another complementor], who is a luminary in crediting and evaluating diseases and everything about them. We had [employee], who also credited, and we had [employee]. They measured leaf mass, diseases, symptoms, the degree of ripeness and acidity.” H1

Similarly, because *machine manufacturer 2* is a machine producer, in-house the firm primarily had mechanical engineers and expertise in this domain. Thus, the company involved two internal people in part-time roles who contributed their know-how. Yet these two employees had difficulties mobilizing further internal resources for the project and only brought other internal people into the meetings from time to time. Beyond these limited operational resources, these complementors provided very little manpower or other resources for operational cooperation. The other partners performed this work and provided this operational module. The role of the complementors was passive. As a result, the initiative clearly lay with the orchestrator, which was the driver of the projects. The complementor can only afford to assume this passive role because it perceives the importance of the ecosystem to be low (*machine manufacturer 2, vineyards*) or its market position, size, or know-how allows it to contribute a module that hardly any other player could provide (*vineyards*). In the *vineyards* case, the size of the wineries as the testing ground is large compared to the area of the other vineyards in the region. According to H1, without the vineyards the amount of data would be significantly lower and so would the probability of obtaining meaningful results. Additionally, the network and reputation of the vineyards have a significant appeal in the region compared to other mostly smaller vineyards. In both the *vineyards* and *machine manufacturer 2* cases, the complementor also supported the collaboration with financial resources, albeit limited:

“We can make investments, but ultimately at this level I am also required to achieve them without writing off investments. And I have to show exactly where this is going.” H1

Links

This low-level contribution of the complementor type A has direct consequences for the orchestrator. On the one hand, it must demonstrate the incentive for the complementor to be part of the ecosystem. For instance, the CEO of *vineyards* demanded a clear definition and calculation of the value for the partner. In order to bind the complementor to the ecosystem, the orchestrator must also offer advantages that go beyond the concrete value proposition. In addition to the abstract prospect of innovation, in the cases this was primarily access to the orchestrator's extensive network. This necessity is demonstrated by the CEO of *vineyards* who wished for more strategic communication:

"Sometimes I wished that I had a report where he said: "Hey, we did this and that, these are the pictures, [...] data transparency in the sense of: How is the project going? What else can we do? That's also very important." H1

The orchestrator therefore needs access to influential decision-makers. In the cases, the contact to these decision-makers happened at rare but regular intervals. They met regularly every few months to discuss further opportunities beyond the current cooperation. Also, AG1 occasionally needs to talk directly to the C-level in order to get support and instruction for the line. In the case of *vineyards*, AG1 had a meeting every two months with the manager of the foundation. Apart from this regular exchange at the strategic level, however, operational communication was deliberately limited. Although there was also an exchange between the individual partners, the orchestrator was usually in the lead. This was also true for the complementor *machine manufacturer 2*, which had phases with a lot of direct communication over the phone (daily to weekly) and other phases in which the contact was almost non-existent:

"We had meetings approximately every month from 2016 to 2018 where we were all together, conference calls or face to face, but the technical driver in the project was [the agriculture data company]." S3

From the point of view of the orchestrator, this type A complementor therefore does not need any tight operational governance to align it to the common value proposition.

Table XVI: Proof for the initial Type A Complementor in Study 3

	Vineyards		Machine Manufacturer 2	
	Classification	Supporting Quotes	Classification	Supporting Quotes
Initial goal of the complementor	<p><i>Gain access to innovation opportunities</i></p> <p>Strong Evidence</p>	<p>"I was more interested in estimating how high something like this could get, where could it end, is it feasible? But clearly, this project does not provide for the basic existence of our winery" H1</p> <p>"And that interested me when I heard that we could look at the digitization. " H1</p>	<p><i>Gain access to innovation opportunities</i></p> <p>Strong Evidence</p>	<p>"What was interesting for us [...] was the know-how in the processing of images, satellite images, soil data and algorithmic knowledge" S3</p> <p>"From an innovation perspective it was very interesting for us" S3</p> <p>"[...] a great value will also come from the agronomic topics. We also have to think outside the box, which is why this project was so important to me" S3</p> <p>"[...] Today, people buy [Machine Manufacturer 2] products because they are robust. It might be interesting to see how we are accepted by our customers, if we could possibly even sell it [the service]" S3</p> <p>"Our core competence lies within machines but not necessarily within the data analysis [...] [the Agriculture Data Company] knows more about the trafficability of a ground, we have more mechanical engineers in the company than agronomists" S3</p> <p>"[the Agriculture Data Company], like other start-ups has a lot of know-how and is very agile. We, on the other hand, are more financially stable [...] if we combine both things, we can develop something together" S3</p>
Initial relevance of the ecosystem for the complementor	<p><i>Lower</i></p> <p>Strong Evidence</p>	<p>"For me it is exciting, and you can use it in the future. But the future is not foreseeable, because in principle we have only recently discovered things. We have seen that we are measuring things that might be directly related to infections, i.e. fungal infections. After all, it's all about yield security. Before that, it was a kind of testing, testing the system, how</p>	<p><i>Lower</i></p> <p>Strong Evidence</p>	<p>"The operational core business simply has a higher priority. Someone buys a machine and you must make sure it keeps working. And with digitization, our customers still have little added value" S3</p> <p>"When we sell a machine, we have an obligation to our customers, I mean with digitization, our customers don't have anything yet, so from there it is</p>

		quickly the data from the hyperspectral camera can be converted into information by a computer. " H1 "It would be a great topic. You could make money, theoretically. You must have a clear definition with a clear objective and that is why we said, I want to have a definition first and a clear structure, what are we doing now. And we have suspended this year because of that" H1		not so much of a rush [...] Digitalization has not yet completely reached the end customer but you can feel that it is coming" S3 "Many take the low-risk approach: invest very little money at the start to see what the results are" AG2 "Especially with machine manufacturers, they have a funding problem and many of them are financed externally, which means that you are not so dependent on the project or you have not yet thought through the business case properly" AG2
Internal Organization	<i>Limited decision-making authority within middle management</i> Strong Evidence	"I'm not the financier. After all, it's [the head of foundation] who's doing the project with him. [...] I get information and I get to watch it. " H1 " [The CEO & Co-Founder] sometimes felt that the decision was mine. But it's not with me. All I can say is, I don't like it, or I think it's good. But maybe it can be the final tip of the scale. But [the Swiss entrepreneur] decides yes or no." H1 "He is basically the bridge [between the head of foundation and us]. Which is supported and he is actually the link [the Swiss entrepreneur] (...) Then it must be legible and [the head of foundation] is someone who reads this business plan and says, I see potential in it or I don't see any potential in it" H1 "But we are still the knot in the middle. The exchange takes place in principle through us" AG1	<i>Limited decision-making authority within middle management</i> Strong Evidence	"The digitization is in the electronics department" S3 "The electronics department is involved in about 100 projects. There are smaller ones, there are bigger ones. And we currently have 70 people active in the department" S3 "We have the electronics centrally; my boss is the global R&D manager. That means we see the electronics in a cross-sectional view. If a new project is started, we discuss whether we will do the project, how we do it, where it will take place. And then everyone who is involved says 'yes, we can do it, I have the resources, or I don't have. " S3
Initial Contribution	<i>Lower</i> Strong Evidence	"There was [employee of another complementor], who is a luminary in crediting and evaluating diseases and everything about them. We had [employee], who also credited, and we had [employee]. They measured leaf mass, diseases, symptoms, the degree of ripeness and acidity" H1 "And he [the orchestrator's assistant] then flew the drone himself on our vineyard. I had no time; I am so involved here" H1 "We can make investments, but ultimately at this level I am also required to achieve them without writing off investments. And I have to show exactly where this is going" H1	<i>Lower</i> Strong Evidence	"It was just me and my superior. We had difficulties, we almost only brought other people into the meetings from time to time [...] I mean, I am responsible for electronics and digitalization which is already a lot" S3 "We then work with machine manufactures to automatically transfer the products or application cards that are to be re-applied to the product in the field, so that it can be placed on the machine and processed" AG1 "It hasn't happened to us yet that partners came up to us and said, we will take that step and then that step

		"Exactly, and the project [...] should also be profitable. [...] We said that we needed sponsors who were prepared to invest money and who would then receive something" H1		[...] the only time we get strategic and operational support from partners is when we talk to the C-level directly, but that does not mean that the line will then decide to do the same" AG1
Initial Exchange with other partners	<i>Regular strategic and limited operational exchange</i> Strong Evidence	"Sometimes I wished that I had a report where [The CEO & Co-Founder] said: "Hey, we did this and that, these are the pictures, [...] data transparency in the sense of: How is the project going? What else can we do? That's also very important" H1 "When the three of us [The CEO & Co-Founder and the head of foundation] would sit and have an information talk, I always thought I felt like an outsider. Because the two of them were talking about things I didn't understand. " H1 "Every second month I see him [head the foundation]" AG1	<i>Regular strategic and limited operational exchange</i> Strong Evidence	"We had meetings approximately every month from 2016 to 2018 where we were all together, conference calls or face to face, but the technical driver in the project was [the Agriculture Data Company]" S3 "Afterwards we agreed to keep in loose contact in case we would like to join again" S3 "We conduct a project-based exchange or sub-ecosystem exchange where we meet with partners and state the next steps and deadlines for the project" AG1
Change of Complementor Type	<i>From type A to type B</i> Strong Evidence	Goal: "Identify where there are infected plants. Maybe even locate the phytoplasma itself, right?" H1 Relevance: "We are very strongly interested because it is a phytoplasma species and, let us say, apparently, it looks like the plant could be freed from the phytoplasma" H1 Relevance: "At least the production can be maintained in the vineyard. Without having to clear the whole plantation. (...) Yes, the work of several years would then be gone and that's not possible" H1 Contribution: "Yes, so we are financing a large part of the whole project" H1 Contribution "We will now help to analyse these phytoplasmas as well. Are they [infected] or are they not? (...) We must expect that we can only do part of it this year. But it should be constructive. And we should be able to build on that next year" H1 Contribution " This is a trainee, an apprentice, a winemaker, a master winemaker. Not all of them will work at it around the clock, but sporadically. On average there will be between five and ten people " H1 Contribution "However, we now have an external research assistant. His capacity is needed when it comes to analysis. He will be in the field and evaluates the plants. How sick	<i>From type A to withdrawal</i> Strong Evidence	"That's why we said it wouldn't do any good. We must stop because I have no time for specific projects. I can initiate something, make sure at the beginning that we motivate people internally, but if nobody takes over, then we cannot do it" S3 "And the difficulty we had is that digitalisation is new for us, a lot of things were new and mobilizing resources internally with customers was a challenge" S3 "The resources are scarce, and one tends then to try to focus on what brings in the money today" S3 "We would have continued if we had had more resources. Clearly. But not everyone in the company was convinced that it would get us ahead. " S3 "I certainly met them at [a fair] six months ago. Not since then. [The CEO & Co-Founder] and [the Chairman & Co-Founder] then gave us an update on their activities. But nothing has changed in our resources that would allow us to continue. " S3

		<p>they are. What stage, so are they completely infected or are they not infected? He has to mark them and puts the plants into his software system" H1</p> <p>Exchange: " [The CEO & Co-Founder] contacted me. He was very fast this time and would be interested in working on it. [...] We then negotiate how we do this. H1</p> <p>Exchange: "We have a very active viticulture commissioner in the canton [...]. He's responsible for the vines. And we've already talked to him and said that [the Swiss entrepreneur] told me that he would like to rebuild the project and that I would ensure that there is also a project. That it is moving forward scientifically" H1</p> <p>Exchange: "We still had a meeting with each other in December. [The CEO & Co-Founder] was also there. (...) So everyone was already involved in this conversation. There were 17 people at the table listening" H1</p>		
Consequence of change for the ecosystem	<p><i>Superior and more specific value proposition</i></p> <p>Strong Evidence</p>	<p>"And we're trying to do that. We do the practical side. We're very much involved, of course. Also, in the evaluation. Because we are personally very much interested in this. And many winemaking colleagues have said that they would like to contribute to the costs in order to be in the project" H1</p> <p>"And we'd run it with like 3,000 vine stock. So, the odds are just going to improve" H1</p> <p>"But it is also true that within the canton, we have a moral position. [...] That's good for the winemaker, but also good for the cantonal government. [...] They want to achieve something together and so I think it would be negative if we were to withdraw from the project" H1</p> <p>I would say, not to appear arrogant or anything, but I think [Vineyards] gives the project a different position" H1</p> <p>"So, the data deterioration would be severe because we provide a relatively large area. So, the probability of getting a result that is meaningful would decrease. " H1</p>	<p><i>Inferior value proposition</i></p> <p>Strong Evidence</p>	<p>"What I heard afterwards is more that they then focus more on more specific issues and needs for the given partners" S3</p> <p>"It can happen that partners are no longer relevant, no longer necessary within the systems because requirements have changed. It could be that the partner did not deliver, or that the customer is not satisfied with the end product, making the whole thing obsolete [...] maybe we also found a better partner that is more suitable or there could be a conflict. Or it doesn't work on the personal level anymore" AG1</p>

4.3.1.2 Type B

Actors

In the cases, the incentive for type B complementors to be part of the ecosystem was clearly defined right from the start. For example, the machine producer *machine manufacturer 1* intended to further develop its innovation platform with the open source concept that connects partners across industries. The company combines agricultural machinery, sensors, and algorithms in such a way that the farmer can flexibly decide which machine is combined with which sensor and which data analysis platform.

Several use cases exist, such as automated irrigation to monitor plant stress, disease detection in viticulture, and the detection of nervousness levels in animals. Thus, the goal of *machine manufacturer 1* in the *Connectivity Services* case was to establish interfaces between the data streams from different providers and effectively merge the functionalities. Similarly, the crop protection company *chemical company* had a clear objective in the *Growth Regulation* case. By using the partners' capabilities in the area of data collection and analysis, *chemical company* wanted to optimize the existing value proposition. With the development of growth regulators, the company intends to gain insights and use an individually adapted and customized solution for each plant. Thus, farmers can get the most from the plant, protect it from the climate, and assure that they only spray pesticides when necessary. On a more abstract level, both complementors *machine manufacturer 1* and *chemical company* had the clear goal of realizing a specific value proposition that incrementally improves an existing product or service. Importantly, the interview partners S2 and GR1 saw this value proposition as being of minor relevance when compared to the overall core business of the organization:

“As far as the project with [the agriculture data company] is concerned, the general added value for us is still very open, because there is still a lot of potential in it.” S2

The internal organization of the complementor reflects this goal. At *chemical company*, a single employee acts both as an interface between the various departments at the complementor and between external partners. Yet this person uses only a fraction of his capacity (one hour a week) for the ecosystem specifically. This is handled similarly at *machine manufacturer 1*. S2 is attached to the marketing function, and together with two colleagues is responsible for managing external partners. This includes the specific project related to the ecosystem, to which S2 only devotes a fraction of its capacity. S2 mostly serves as an interface between the various internal functions. Thus, in both cases, an employee with limited decision-making authority works in a position that serves as an interface for several functions and different projects. He does not have significant resources of his own, and therefore must try to acquire operational staff from other departments for specific projects, such as an ecosystem cooperation.

Contribution

Due to this internal organization at the complementors, the resources available to these complementors were limited and so was their contribution to the ecosystem. For instance, the manager of the *agriculture data company* originally wanted to have 100 test fields provided by the complementor *chemical company*. However, due to internal restrictions, the decision-makers at *chemical company* decided to reduce this to five fields. In addition to their test fields and know-how, the module provided by the complementors also includes significant operational capacities. For example, *chemical company* contributed specialist personnel from various functions (8 FTE). These employees worked from around an hour up to three hours a week for the specific project:

“What [the agriculture data company] really doesn't have is the resources and the manpower we have [...]. We have a marketing manager. And a technician. [...] We had another one with us, [...] one that comes from the digital side.” GRI

Machine manufacturer 1 provided four employees altogether: two external doctoral candidates and two internal co-workers. For the implementation of the interfaces, they involved and managed the technical interests from the engineers, as well as the business and innovation interests from the marketing and R&D departments. In general, these employees could autonomously decide how to use their own budget. However, as soon as additional resources were required, these decision-makers reached the limits of their internal power. According to S2, the difficulty begins the moment he needs a team and starts to argue for additional manpower from other departments and stakeholders. Because of this limitation to their own budget and resources, the decision-makers at the complementor type B must choose between opportunities and can only contribute limited resources to a specific ecosystem. The Alliance Manager Europe at *machine manufacturer 1* nicely illustrates this necessity:

“And unfortunately, this also means that certain projects, no matter how great they may be, cannot be driven forward here with the highest priority.” S2

Links

This pressure has direct consequences for the orchestrator. In order to maintain the complementor’s contribution at the required level, the orchestrator has to account for its goal. The orchestrator must therefore continuously demonstrate the added value of the specific value proposition to the decision-makers within the complementor firm. The Head of Crop Enhancement at *chemical company* expected the orchestrator to demonstrate that the system would work. This was particularly important considering that the individual ecosystem was nowhere near as important for the complementor as it was for the orchestrator.

“If you now talk specifically about [the agriculture data company], it is certainly a secondary war venue that doesn’t have so much priority.” GR1

A regular and frequent exchange with the decision-makers at the complementor is therefore necessary, and the orchestrator must manage these exchanges closely. In the case of *chemical company*, the complementor and

the orchestrator had two one-day workshops. Furthermore, a weekly exchange in the form of a regular one hour call every Friday afternoon took place. This communication was bilateral, meaning that the complementor only had indirect contact to the other actors via the orchestrator. AG1 explained that a multilateral discussion would not be feasible, since he is one of the few people who has an overall view of all of the partners. Similarly, regarding *machine manufacturer 1*, there were several calls and meetings at fairs and on site at the *agriculture data company* and the offices of *machine manufacturer 1*. Thus, communication was primarily the responsibility of the orchestrator. In addition to providing their own module, this active alignment of the partners was a core challenge for the orchestrator:

“We are the driver within the project, and if we didn’t do it, no one would.” AG1

With a type B complementor, the orchestrator must therefore focus governance on aspects that relate primarily to the specific ecosystem and permanently show the value for the complementor.

Table XVII: Proof for the initial Type B Complementor in Study 3

	Machine Manufacturer 1		Chemical Company	
	Classification	Supporting Quotes	Classification	Supporting Quotes
Initial goal of the complementor	<i>Realization of incremental value proposition</i> Strong Evidence	"It should be as diverse as possible, cover as many different perspectives as possible, and should incorporate the most diverse technologies" S2 Manufacturer 1 intended to further develop its innovation platform with the open source concept that connects partners across industries. Specifically, it combines agricultural machinery, sensors, and algorithms in such a way that the farmer can flexibly decide which machine is combined with which sensor and which data analysis platform. Several use cases exist, such as an automated irrigation system of plant stress monitoring, disease detection in viticulture, and the detection of nervousness levels in animals. Thus, the goal of machine manufacturer 1 in the Connectivity Services case was to establish interfaces between the data streams from different providers and merge the functionalities	<i>Realization of incremental value proposition</i> Strong Evidence	"Our concrete goal was to eventually go to market with a finished product" GRI "The market is characterized by strong competition and little innovation, and the individual companies have to think of ways to set themselves apart from the competition. And [the Agriculture Data Company]'s tool was just right for us to take a look because digitalization is also a buzzword for us" GRI "Chemical manufacturers have their pesticide and are looking for solutions at some point where they can apply it with a digital service." AG2
Initial relevance of the ecosystem for the complementor	<i>Lower</i> <i>Strong Evidence</i>	"As far as the project with [the Agriculture Data Company] is concerned, the general added value for us is still very open, because there is still a lot of potential in it" S2	<i>Lower</i> <i>Strong Evidence</i>	"If you now talk specifically about [the Agriculture Data Company], it is certainly a secondary war venue that doesn't have so much priority." GRI "We were not really convinced by the solution at the start, so we wanted to try it within a small scale [...] and when it worked, we enlarged the scale" GRI
Internal Organization	<i>Limited decision-making authority within middle management</i> Strong Evidence	"We are two people who are driving this forward [...] We see, there are different interests, and the difficulty here is getting the priorities right. Because, as you can imagine, we are a global corporation. We are already fighting for resources" S2 "Whatever I can do today, I can do immediately, so I do not have to ask anyone. For everything that is leading to changes it gets difficult because we then	<i>Limited decision-making authority within middle management</i>	"We have a marketing manager. And a technician. [...] We had another one with us, [...] one that comes from the digital side" GRI

		need a team and someone that defines it and so on [...] we also have to try to collect as many arguments as possible in order to be able to push certain things forward [...] and for these difficulties you might need the support of other departments and stakeholders" S2	<i>Strong Evidence</i>	
Initial Contribution	<i>Medium Strong Evidence</i>	"In the last discussion, we were four, two PhD students and two in-house employees, as well as me. I rarely get 100% for a project" S2	<i>Medium Strong Evidence</i>	"What [the Agriculture Data Company] really doesn't have is the resources and the manpower we have, as well as economies of scale" GRI "We also have the experience, since we have brought the product to market" GRI "There were about eight people involved [...] I would say about an hour a week, [...] some people 2-3 hours a week in hot phases" GRI "We have [the Chemical Company and another chemical company] with us, which provide us with a high amount of data and trials we need" AGI
Initial Exchange with other partners	<i>Regular strategic and operational exchange Strong Evidence</i>	"This conversation in particular is extremely important, because in my opinion this is how innovation is created. The partners have different core competencies and perspectives and through the exchange with other partners, eyes open up" S2 "We met them at several fairs and had a lively exchange. There were also mutual invitations. [...] there was a project where we wanted to gather some feedback to evaluate the potential" S2 "We had an annual conference for the last year, which will take place again, where we invite companies to come to Mannheim for a day or two to discuss with us and to exchange ideas [...] and we also conduct a developer conference" S2	<i>Regular strategic and operational exchange Strong Evidence</i>	"We had direct contact with [the Agriculture Data Company] and the farmers, but not with the other research and development partners of [the Agriculture Data Company]" GRI "We even had, I think, a weekly call during the hot phase. So, for two, almost three months, we spoke for an hour every Friday afternoon. It was a weekly exchange which was sometimes over after ten minutes, but sometimes lasted an hour and a half" GRI "It was a very intense exchange, especially in operational topics [...] I think we were equal partners, whereby [the Agriculture Data Company] was the one who conceptually developed the service to implement the structure [...] it was [the Agriculture Data Company] in the driver's seat but we were fully involved" GRI "We are the driver within the project, and if we didn't do it, no one would" AGI
Change of Complementor Type	<i>From type B to type A Strong Evidence</i>	"And that unfortunately includes the fact that certain projects, however great they may be, cannot be given the highest priority here" S2	<i>Type B to type A to withdrawal Strong Evidence</i>	Type B: "We were not really convinced by the solution at the start, so we wanted to try it within a small scale [...] and when it worked, we enlarged the scale" GRI Type A: "It is certainly a side project and growth regulators are limited and the market is small [...] but

		<p>"Unfortunately, in a large corporation today, priorities shift, [...] we try to be on all the companies, but that just doesn't always work" S2</p> <p>"We provide contacts and knowledge. We provide an interface that can be used by partners, and if we find that there is a win-win situation, we look at how we put the teams together" S2</p>		<p>we could apply it to more things and make it more important again" GRI</p> <p>"It was a proof of concept for us. [...] With the idea that something like this can only survive if you can let it continue to grow" GRI</p> <p>"We'll probably have to get back to our 'editing table' ourselves and think about where we're going. And what do we want to achieve with it? [...] Maybe you should think about what the end should look like before you start something" GRI</p> <p>Withdrawal: "The two farmers did indeed go through with it, but we stopped it with [the Agriculture Data Company] at the end of last year. So, they approached us again and wanted to repeat it this year, but for us it was still too immature for us to put more money into it. Since we are doing research in a similar direction anyway and have cooperations with other, bigger companies, we said that the advantage we thought [the Agriculture Data Company] had did not prove to be true and that's why we stopped the cooperation with [the Agriculture Data Company]" GRI</p> <p>"And he said a year ago, the thing works, you can go commercial right away. Fiddlesticks, it was oversold and underdelivered, that's what I told him. And therefore, well, if he had actually been as far as he said, I could have imagined very well that we would have done that this year and then a competition would have been created internally, also for resources, a four-figure decision to stop it." GRI</p>
Consequence of change for the ecosystem	<i>Completion of initial value proposition Strong Evidence</i>	"When it comes to simply integrating the data exchange functionality with the [the Agriculture Data Company] platform, it is pretty much done" S2	<i>Ecosystem collapse Strong Evidence</i>	After the decision to terminate its contribution and close the test fields, the project was suspended.

4.3.1.3 Type C

Actors

In the two cases *Disease Detection* and *Connectivity Services*, type C complementors were small application-oriented research facilities. The value proposition to be developed was clearly defined at the beginning, as was the contribution of the complementor. The core competencies of the individual partners had to be bundled in close coordination. For example, in the *Disease Detection* case, *research institute* wanted to develop a concrete value proposition in the field of precision arable farming, which it was not capable of doing alone. It needed industry partners and end users for guidance. The complementor was characterized by a small, agile, and autonomous project team made up initially of two people who could make decisions for their team:

“They were two people from F. [...] There is central control, but it has relatively little influence on the content of the institutes. As long as we are profitable, you can really do what you want.” H2

This autonomy also entails the pressure of self-financing. This is an important reason why the success of the ecosystem is of central importance to the complementor. This dependency is a key difference between C-type complementors and the complementors of types A and B. The managers of the *research institute* managed this by contributing a strong module to the ecosystem.

Contribution

The module consisted of a 3D laser scan system, which had to be developed for a specific agricultural machine. The complementor developed this system in close coordination with the other players in the ecosystem, so that the group could ultimately create a 3D model of the vineyard based on multiple data sources.

“We developed sensors and data processing and made them available. I went into this vineyard and then measured the vineyard with this tractor.” H2

Shortly after the start of the project, the complementor had developed an irreplaceable module and was no longer an interchangeable within the ecosystem. Furthermore, the complementor’s contribution was high. The Project Leader of the *research institute* allocated one third of its capacity to the ecosystem. Naturally, the *research institute* was not able to be deeply involved in other projects or ecosystem initiatives, which also increased its dependence on this specific ecosystem. The successful cooperation of the key partners in the *Disease Detection* case was an indispensable prerequisite for the formation of the much larger (ten times larger in terms of financial funding) ecosystem in the *Connectivity Services* case.

Links

Due to this equivalent mutual dependency, the orchestrator and this type of complementor are equals with the ecosystem:

“That [cooperation with these research institutions] is actually always at eye level. [...] They were all highly motivated and made good contributions.” H2

As a result, the orchestrator does not have to offer any further advantages to the complementor beyond the close project work, and can instead concentrate on the project-specific exchange. This exchange is both very close and regular (weekly). At the same time, all actors of this type know each other, communication is both bilateral and multilateral and is carried out through various channels such as emails, phone calls, or personal meetings. In addition to the frequent bilateral consultations, there was also frequent exchange on a large scale, with the core partners meeting physically. As such, in the *Disease Detection* case, the partners met either in Italy or in the Swiss winery a total of four times in two years to coordinate the technology and test it together. Thus, the orchestrator must closely guide C-type complementors operationally in order to align them to the common value proposition.

“And the task of such a coordinator is to collect all these individual works and all these, well, crazy scientists, and then to stretch the whole thing out and bring a red thread into it.” H2

Table XVIII: Proof for the initial Type C Complementor in Study 3

	Research Institute	
	Classification	Supporting Quotes
Initial goal of the complementor	<i>Realization of important value proposition</i> Strong Evidence	"It was also about precision farming and farm management. And we were looking for a partner who also operates a farm management system of this kind. There are not too many manufacturers or companies that do that" H2 "Our goal at [the Research Institute] is to develop and integrate data for research work in the field of agriculture. Tasks that arise in this area range from data consistency to precision farming tasks. Here we want to develop applications, and for this we need end users who guide us and tell us what is important, what is needed, and what is not needed" H2
Initial relevance of the ecosystem for the complementor	<i>Higher</i> Strong Evidence	"In these research projects one usually needs an industry partner, especially if, like [the Research Institute], one is doing this application-oriented research. And besides, I must also say that you are always grateful when someone takes part. But in the case of [the Agriculture Data Company], this also fit in very well in terms of content" H2 " [The Agriculture Data Company] is, from our point of view, an end-user for algorithms, for procedures based on data" H2
Internal Organization	<i>Small and autonomous project team</i> Strong Evidence	"They were two people from F. [...] There is central control, but it has relatively little influence on the content of the institutes. If we are profitable, you can really do what you want" H2 "In the project we did in [Vineyards], there were two people from [the Research Institute], me and another colleague" H2 "In the Atlas project, it has grown in the meantime. So currently there are five of us and now students are joining. I spend fifty to sixty percent of my time on the project. The other four employees actually write down fifty percent of their time. " H2
Initial Contribution	<i>Higher</i> Strong Evidence	"We developed sensors and data processing and made them available. I went into this vineyard and then measured the vineyard with this tractor" H2 "Our focus is this laser scan analysis and AI systems for decision support and image evaluation of video surveillance data from stables, pigsties, cowsheds" H2
Initial Exchange with other partners	<i>Regular strategic and frequent operational exchange</i> Strong Evidence	"That [with these research institutions] is actually always at eye level. [...] They were all highly motivated and made good contributions" H2 "And the task of such a coordinator is to collect all these individual works and all these, well, crazy scientists, and then to stretch the whole thing out and bring a red thread into it" H2 "We have communicated via e-mails, conferences, or personal project meetings. In [Vineyards] where we put it all together and tested it. That is when we agreed on what should be done and how it should be used. So, the whole thing was again a very dynamic process" H2 "We have been to either Italy or [Vineyards] a total of four times. Campaigns where we really tried technology. That was four times in the two years. And a whole bunch of e-mails went back and forth, of course. And probably phone calls every two or three months. The exchange was very, very active" H2

		<p>"The relationship is relatively close. So that you really worked together in this winery and needed something. That very quickly became a close and very collegial relationship. " H2</p> <p>"For the Atlas project it is at least twice a week. We have a lot of contact and by e-mail almost every day. We met in December, and in January we met personally with a machine producer in Bavaria" H2</p> <p>"With thirty partners, you always have a few key players with you. I have a similar amount of contact with the agricultural machinery manufacturers. And with some of the research partners. I have a partner from the Cologne University of Technology (and others) with whom I work relatively closely. Now it's also very close and they have tractors with them where you can test something. But I would say that most of the work is already focused on [the Agriculture Data Company] and the agricultural machinery manufacturers" H2</p>
Change of Complementor Type	<p><i>Type C to orchestrator</i></p> <p>Strong Evidence</p>	<p>"We said that we didn't want to do it ourselves, so [the Research Institute] is the lead and we are more of a co-lead. " AG1</p> <p>"This will not be the case, where [the Research Institute] is in the lead. But we are the core party because we provide the core system" AG2</p> <p>"It would be bad for us if it failed in such a way that we had to pay back the money. Of course, we would also lose our reputation, which would be bad for future projects. So, it is not an option for us to withdraw from the project. We are not doing that" H2</p>
Consequence of change for the ecosystem	<i>Ecosystem collapse</i>	<p>"That would have dramatic consequences. We would then no longer be able to do a large part of the project. And then the EU would probably want its money back" H2</p> <p>"So, we have a consortium of agricultural machinery manufacturers. And there are all the major agricultural machinery manufacturers in the consortium. They won't go bankrupt, but they're key players in terms of industrial representation. And if they say, 'No, we're not doing it anymore, it's no good for us', you've got a problem. Or the ones who are members, to get them in there one by one, that would be bad, if that happened" H2</p>

4.3.2 Dynamics between the individual Types

In the cases, a single complementor could adjust its contribution and thus change its type over time in the continuum. This happened due to changing goals for the complementors with regard to the ecosystem. At the beginning of the cooperation, some complementors started as Type A and tried to shape the operational cooperation efficiently. The decision-makers at the complementor regularly assessed whether they should end, maintain, or expand the cooperation. For complementor *chemical company*, a decisive question was whether its own contribution to the ecosystem should be increased. The Head of Crop Enhancement at *chemical company* formulates it as follows:

“It was a proof of concept for us. [...] With the idea that something like this can only survive if you can let it continue to grow.” GRI

With the decision to make significant operational resources available and involve eight people, *chemical company* started as type B as described in the previous section. The focus of the complementor was on the realization of a specific value proposition adapted to its needs, and a minimization of operational resources was not a priority objective. On the other hand, *chemical company* had to continuously evaluate the utility of the value proposition. When the reward did not materialize as expected, the company's own operational contribution was sharply reduced. The Head of Crop Enhancement at *chemical company* describes the former status quo as follows:

“We'll probably have to get back to our 'editing table' ourselves and think about where we're going. And what do we want to achieve with it? [...] Maybe you should think about what the end should look like before you start something.” GRI

Thus, *chemical company* changed to be type A complementor and optimized its own efficiency until further notice. The complementor's module in the ecosystem included two testing fields and ongoing measuring and evaluating

of the results. At the same time, the decision-makers at *chemical company* explicitly kept open the possibility of increasing their own contribution again and of providing more manpower or other resources. This would be an option if the value proposition could be applied to more of the services of *chemical company*, thus becoming scalable and more important for the corporation. However, after six more months, *chemical company* decided to stop the project. According to GR1, the primary reason was that the solution was too immature for the firm to contribute more resources. Also, *chemical company* had other cooperations with bigger companies involved and wanted to bundle its resources.

“And he said a year ago, the thing works, you can go commercial right away. Fiddlesticks, it was oversold and underdelivered, that’s what I told him. And therefore, if he had actually been as far as he said, I could have imagined very well that we would have done it this year.” GR1

The situation was similar at *machine manufacturer 1*, which started as a type B complementor as described in the previous section, providing operational resources for the integration of data. However, as soon as this first value proposition was completed and this goal achieved, the complementor mutated to type A and significantly reduced its own contribution. In order for the complementor to provide further operational resources, it would have to have a clearly defined incentive. Employed at a global corporation, the decision-maker S2 needs specific arguments in order to prioritize a project and receive additional resources. However, the main interest of the complementor now lay primarily in the exchange with the orchestrator and the opportunity to innovate:

“This conversation in particular is extremely important, because in my opinion this is how innovation is created. The partners have different core competencies and perspectives and through the exchange with other partners, eyes open up.” S2

The firms currently have a lively exchange of ideas about further projects that might be feasible. For the Connectivity module, *machine manufacturer 1* therefore primarily provides know-how, but barely any operational resources. However, the complementor reserves the right to provide more operational employees again in the future and thus to change the type again. According to S2, the discovery of interesting opportunities and the rise of a win-win situation for all sides always leads to a new analysis, including of its own required effort and resources.

More static was type C. This resulted from the strong dependency on the success of the project, whereby the contribution of the complementor could not be reduced. Instead, the contribution of a type-C complementor could even increase. A nice example is the *Connectivity Services* case and the role of the *research institute*. Compared to the *Disease Detection* case, the complementor in the *Connectivity Services* case provided even more resources:

“It has grown in the meantime. Currently there are five of us and now students are joining. I spend fifty to sixty percent of my time on the project. The other four employees actually write down fifty percent of their time.” H2

The technical module of the *research institute* is a laser scan analysis and AI system for decision support and image evaluation of video surveillance data from stables. On top of this, H2 also officially took over the project coordination and, thus, the *research institute* became a co-orchestrator of the ecosystem. As a result, H2 has weekly contact with some key players, such as the agricultural machinery manufacturers, and almost daily exchanges with the agriculture data company. Since the *agriculture data company* is responsible for the software architecture of the overall system as well as the interfaces with the farmers, it still acts as a (co-)orchestrator.

“We are the core party because we provide the core system.” AG2

Thus, neither the *agriculture data company* nor the *research institute* can withdraw from the project and leave the ecosystem. Also, a failure of the project would cause a loss of reputation, which would be bad for future projects. In an extreme case, all partners would also have to pay back funding, which is not an option for small entities. Thus, the complementor type C cannot reduce its contribution.

“So, it is not an option for us to withdraw from the project.” H2

At the same time, in the cases the risk that a complementor will leave the ecosystem increases as its contribution decreases. Type A complementors in particular are therefore susceptible to withdrawal. The minor reward from the value proposition can tempt the decision-makers at a type A complementor to reduce their own contribution and speak regularly with the orchestrator only about innovation and cooperation potential. This has happened in the cases with *machine manufacturer 2*, *chemical company*, and almost with *vineyards*. In the first case, after two years *machine manufacturer 2* called the added value of the ecosystem into question due to the limited resources available and because not everyone in the company was convinced that it would get them ahead:

“That's why we said it wouldn't do any good. We must stop because I have no time for specific projects. I can initiate something, make sure at the beginning that we motivate people internally, but if nobody takes over, then we cannot do it.” S3

For these reasons, the complementor decided to terminate the cooperation and thus to withdraw from the ecosystem. According to the scientific definition (Adner, 2017), this lack of a value proposition means that there would no longer be an ecosystem and thus the partner would not be a complementor. Still, the partners agreed to keep loose contact in case *machine manufacturer 2* decides to re-join the cooperation. They met again at a fair several months later and the *agriculture data company* provided an update on their activities.

But the resource problem at *machine manufacturer 2* had not changed, and they remained unable to resume the cooperation.

In the *Disease Detection* case, after three years the CEO of the *vineyards* demanded a clearer concept because the added value of the value proposition was too uncertain. Thus, the CEO made an assessment and compared the cost of his own contribution with the benefit to be derived from the ecosystem. Since the reward did not materialize as expected, the complementor decided to suspend its contribution:

“If I invest a lot of money, I'd like to know what I'm getting [...] I want to have a clear definition first, on the basis of which I can calculate. And that's why we suspended the project this year.” H1

This suddenly changed again two months later after an external shock in the form of an infestation of the phytoplasma bacterium, which destroyed 20% of the harvest. According to H1, without countermeasures, the course would have spread to the entire vineyard, so that the entire stand might have to be cleared. If detected early however, infested vines can be cut back by hand. Early detection of the infestation is therefore extremely valuable to prevent it from spreading. As a matter of fact, the infestation was first identified by the agriculture data company's analytics two years earlier, although the impact remained unclear:

“Two years ago, we first saw it through the project with [the agriculture data company]. There were 25 plants out of about 50,000 infected, which [the agriculture data company] specifically identified through data analysis.” H1

Due to the rapid spread of the bacterium and significant crop failure in autumn 2019, the fight against the infection suddenly became a priority for *vineyards*. Decision-makers at *vineyards* therefore decided to significantly expand the disease detection project and intensify the cooperation. Because of the infection, the potential reward from the value proposition for *vineyards* was now clear and specific. H1 described it as identifying the infected plants and

ideally locating the phytoplasma itself. The incentive for *vineyards* was now clearly quantifiable as lowering crop losses. This becomes even more relevant considering that the bacteria are expected to remain at the vineyard and threaten the harvest for several years. Thus, the partners planned to renew the cooperation to form an ecosystem over the next few years. In addition to the *agriculture data company's* original partners, *vineyards* and several research institutes, this time there are several other smaller vineyards that suffer from the same regional problem involved. Thus, some public research institutions should also be involved. For instance, the national centre for excellence in agricultural research should provide expertise about the disease and support communication with the smaller wineries. As for the complementor *vineyards* itself, the management increased its contribution in two ways. Financially the decision-makers at *vineyards* were now willing to invest a significant amount of money to create financial incentives for the other partners, such as the *agriculture data company*. Operationally, almost all employees of *vineyards* are now involved in examining the plants.

“This is a trainee, an apprentice, a winemaker, a master winemaker. Not all of them will work at it around the clock, but sporadically. On average there will be between five and ten people.” H1

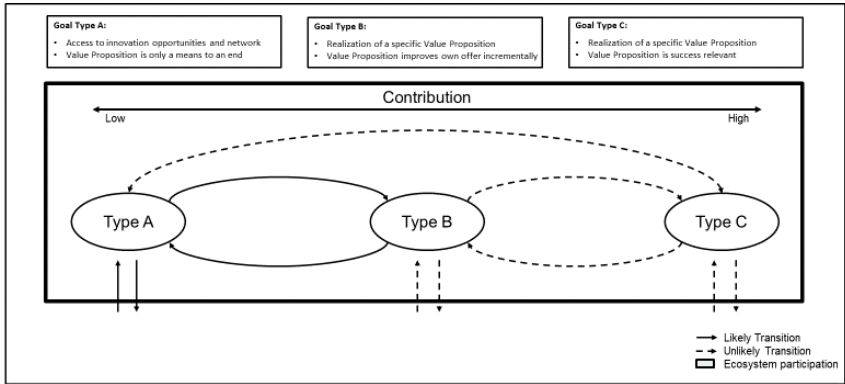
Another external research assistant assesses the degree of disease in the field for each individual plant, marks it, and records the data. These data are then matched with the actual and historical data recorded by the hyperspectral camera from the *agriculture data company*. Once the analytics have provided insights about the infected plants, the employees can physically evaluate them in the field and cut the individual plants. Based on this clear incentive for the winery to be part of the ecosystem, H1 has thus changed back to being a complementor of type B. This change provides an excellent example of how an external shock can lead to a higher incentive for a complementor to change its contribution to the ecosystem.

The interplay between types A and B results in criteria that determine the transition between the types. Thus, interestingly, in the cases either the decision-maker from the complementor firm makes the decision about the contribution or the required contribution has decreased. Therefore, *chemical company*, *machine manufacturer 1*, *machine manufacturer 2*, and *vineyards* continuously reassess their reward and make their own contribution dependent on it. The more concrete the objective and the increasing added value of the value proposition, the stronger the contribution becomes. Conversely, dissatisfaction with the progress of the project (*chemical company*), lack of an added value from the value proposition for the complementor (*vineyards*, *machine manufacturer 2*), or the completion of a sub-project (*machine manufacturer 1*), leads to a reduction in contributions. The complementors then either withdraw from the ecosystem or minimize their operational contributions as type A complementors.

“It can happen that partners are [...] no longer necessary [...] because requirements have changed. It could be that the partner did not deliver or that the customer is not satisfied with the end product.” AG1

The cases allowed for a detection of several transitions between type A and type B, whereas we did not observe a transition between types B and C or between types C and A. Figure 8 provides an overview of the dynamics between the three complementor types.

Figure 8: Framework of three Types of Complementors



4.3.3 Consequences of Dynamics for the other Actors

The last aspect to consider are the consequences of these dynamics for the other actors. A change in type, and therefore a change in a complementor's contribution, has consequences on an ecosystem level due to the multilateral interdependencies of the actors. As described in the section above, this change of contribution seems to be an option only for types A and B in the cases.

When *machine manufacturer 2* withdrew from the ecosystem, the other partners continued with the connectivity project. Since the interfaces from *machine manufacturer 2* were now missing, the final value proposition became less than what was initially intended. However, the ecosystem per se was not threatened because of the presence of the other machine producers, such as *machine manufacturer 1*, who still provided their interfaces and machines. Additionally, they could focus more on the specific interests of the other machine producers:

“What I heard afterwards is more that they then focus more on more specific issues and needs for the given partners.” S3

In the *Disease Detection* and *Growth Regulation* cases, I could observe a similar pattern, even though the consequences for the ecosystem were significantly more severe. When *chemical company* reduced its contribution, the testing capabilities and data quality were limited, and the value proposition became significantly inferior. After the decision of *chemical company* to terminate its contribution, the ecosystem collapsed. In other cases, the ecosystem itself might be threatened. For instance, once the initial type A complementor *vineyards* decided to suspend the cooperation and closed the test fields, its partners could not collect new data on these fields. They would probably have found other wineries, but these would likely have been smaller and with deeper reputations.

“It wouldn't break down. There are other people behind this who also have a will. And they would pull themselves together. Not to seem arrogant, but we're giving the project a different position.” H1

After the severe infection with the phytoplasma and the decision of *vineyards* to expand the cooperation, the situation changed significantly for the complementors. The financial support from the foundation, as well as from the cantonal institutions, created security for the partners. The quality of the data was also increased. Thus, their incentive and potential reward also increased with the higher contribution of *vineyards*.

These three cases show that the fungibility of the individual complementor has a major impact on the consequences for the ecosystem of a complementor's withdrawal. The lower the fungibility of the complementor, the greater the consequences for the other actors. However, if a complementor such as *machine manufacturer 2* provides a module similar to that from another set of actors, such as the machine producers, its ecosystem withdrawal has fewer consequences for the ecosystem. Only if all the players of a set of actors, such as the machine producers, left an ecosystem, would the overall structure be threatened. H2 nicely explains this:

“There are all the major agricultural machinery manufacturers in a consortium. They [are] key players in terms of industrial representation. And if they say: ‘No, we’re not doing it anymore’ [...] you’ve got a problem.’ **H2**

The withdrawal of a complementor that is not particularly fungible is problematic primarily for the orchestrator, as well as for the highly committed complementors such as type C complementors. The value proposition of the specific ecosystem is far more important for these types of actors, which makes it crucial to keep the other complementors in the ecosystem. H2 describes this hypothetical scenario for the *Connectivity Services* case:

“That would have dramatic consequences. We would then no longer be able to do a large part of the project. And then the EU would probably want its money back.”
H2

The orchestrator must therefore try to proactively prevent the complementors from reducing their contributions. Most importantly, the orchestrator must set different governance priorities after a change of type for the complementor. As shown in the previous section, the goal of a type A complementor is significantly different than the goal of a type B complementor. Thus, the orchestrator needs to constantly track the goals of the other complementors and react accordingly (see Table XV). For instance, the CEO of the *agriculture data company* remained in regular contact with the decision-makers at *vineyards* after the temporary suspension of the project. When the situation with the bacteria infection arose, he could quickly suggest a specific solution based on the previous cooperation of the partners:

“[AGI] contacted me. He was very quick this time.”
H1

These findings show how the actors in the three ecosystems approach the contribution-reward trade-off between one complementor and the other actors. Type A and B complementors are more likely to reduce the own contributions

towards the ecosystem when their goals change or the reward turns out to be less than expected. The orchestrator and type C complementors do not have this option since they are dependent on the specific ecosystem. Therefore, they maintain their contributions on a constant level. Furthermore, the orchestrator primarily optimizes the reward for the fragile complementors to incentivize them to remain in the ecosystem.

5 Discussion and Contribution to Literature

In this chapter I discuss the theoretical contributions of this dissertation. As described in the previous chapters, my three multi-case studies each have their own research focus and address specific research gaps in the ecosystem literature. Therefore, I structure the contributions along the three major research topics organizational structures and information processing, orchestrators and complementors.

5.1 Contribution to Ecosystem Literature on Information Processing

In the following section, I discuss the empirical findings on the novel field of information processing in ecosystems. The first major theoretical contribution is the framework provided in Figure 6. It reveals three patterns of information processing structures in ecosystems, based on the inherent power of the orchestrator and the required amount of processed information. These patterns show the implications of the information processing design on the use of the orchestrator's information capacity and the timeliness of processing information. Besides these apparent insights, my research focus offers a two-fold contribution. Primarily, I contribute to an understanding of information processing in ecosystems. In addition, some findings provide further general insights to existing ecosystem literature and create potential pathways for future research on ecosystems (Adner, 2017; Jacobides et al., 2018).

First, study 1 sheds light on the aspect of information processing structures that allow for either efficient or flexible information processing. In the cases, the design of this structure depends on the inherent power of the orchestrator. The existing literature on ecosystems has discussed whether formal mechanisms and rules are being used by the orchestrator to steer ecosystem members (e.g. Alexy et al., 2013; Baldwin, 2012; Brusoni & Prencipe, 2013; R. Gulati et al., 2012; Leten et al., 2013; Teece, 2016b). The findings show that an inherently strong orchestrator is more likely to set up an information processing structure that allows for efficient information processing, which, in turn, implies a

higher degree of formalisation. The weaker the orchestrator, the more the ecosystem is likely to be managed by informal mechanisms and flexible arrangements among the partners.

These reasonings point towards another aspect as well: The value created by an ecosystem hinges on the use of complementarity effects among the modules provided by the partners. This requires the latter to co-specialise, i.e. to adjust their respective modules to each other (Jacobides et al., 2018, p. 2257). From an information processing lens, this requires ecosystem members to receive information related to the other partners' modules and actions. An efficient information processing increases the speed and accuracy of such perceptions and actions (Ocasio, 1997). As a consequence, we can expect that ecosystems steered by an orchestrator with a stronger position, which is facilitating efficient information processing and free flow of information, are making better use of complementarity effects, thus creating more value for the customer.

In the second aspect under consideration, study 1 delves deeper into the management of the actors within the ecosystem by the orchestrator. Although several authors have considered the steering of the partners by the orchestrator to be a key characteristic of ecosystems (e.g. Alexy et al., 2013; Baldwin, 2012; Brusoni & Prencipe, 2013; Leten et al., 2013; Teece, 2016b), this aspect is still not sufficiently understood (Jacobides et al., 2018). I show that orchestrators purposefully shape information processing structures within ecosystems in order to distribute or withhold information.

This aspect is directly connected with another key question of ecosystem management: Prior works on ecosystems, such as Alexy et al. (2013), Brusoni and Prencipe (2013), and Frankort (2013), analysed how knowledge sharing affects the strength of inter-firm relationships and, thus, the development of the ecosystem. However, “the mechanisms of how hub firms manage knowledge mobility have rarely been studied (for exceptions, see Azzam, Ayerbe, and Dang (2017) or Pellinen, Ritala, Järvi, and Sainio (2012)) and

empirical support remains limited even within these studies” (Jacobides et al., 2018, p. 2257). I show that the design of information processing structures regulating the information exchange between the partners in an ecosystem is significantly determined by the orchestrator’s inherent power. The orchestrator steers the ecosystem partners by using different patterns of information processing structures in order to distribute or withhold information, thus influencing the actors’ timeliness of processing information within the ecosystem. If an orchestrator has a strong position within the ecosystem, it is likely to create an information processing structure that ensures a free flow of information between the partners. Thus, if a firm intends to benefit from information exchange and learn from other partners, it should engage in an ecosystem with an inherently strong orchestrator. An orchestrator with a weak position, however, is likely to limit the partners’ access to crucial information in order to maintain its position as the ecosystem leader.

This, also, points towards a significant difference between the logic of ecosystems as a subset of alliances (Jacobides et al., 2018, p. 2257) and the findings of the network and the alliance literature. The latter primarily uses the perspective of information and knowledge exchange for such constructs (Ahuja, 2000; Burt, 1992; McEvily & Zaheer, 1999; Muthusamy & White, 2005; Powell, 1998; Powell et al., 1996; Tsai & Ghoshal, 1998; Uzzi, 1996, 1997). Accordingly, several studies have shown that knowledge building and transfer is of fundamental importance for the success of alliances (Doz, 1996; Dussauge, Garrette, & Mitchell, 2000; Khanna, Gulati, & Nohria, 1998; Sammarra & Biggiero, 2008). In this vein, ecosystems being led by an inherently strong orchestrator can serve similar purposes in terms of knowledge transfer and learning between actors involved as alliances or networks. However, this does not apply to ecosystems with weak orchestrators.

Lastly, the findings introduce a surprising notion: That ecosystem orchestrators need to invest more information capacity into managing the ecosystem when their position is inherently weak. Thus, the stronger the inherent position of the orchestrator, the smaller the information capacity, i.e. the team size, needed to

manage an ecosystem. On the other hand, if an orchestrator firm has an inherently weak position, it should allocate a larger team to the management of the ecosystem. This is an important finding, and not just for corporations setting-up ecosystem initiatives. It might also be crucial for smaller corporations or start-ups and their success as orchestrators, since these firms are often dealing with a lack of resources and manpower.

5.2 Contribution to Ecosystem Literature on Orchestrators

In this section, I discuss the empirical findings of the second study and show how they contribute to existing literature on orchestrators and create potential pathways for future research on orchestrators in ecosystems.

The findings contribute to research on the ecosystem concept and shed light on the largely under-researched topic of how firms allocate orchestrator tasks to specific participants in an ecosystem. First, the study delves deeper into the management of actors within the ecosystem. As such, I address the recent call by Jacobides et al. (2018) to address the fact that the steering of partners is not sufficiently understood. With these findings, I open this black box and illustrate three patterns of actor management approaches. These findings provide “a clearer sense of how ecosystems are structured and governed” (Jacobides et al., 2018). The separation of strategic tasks (those that define the value proposition and bring new ideas) and operational tasks (those that implement the value proposition and coordinate suppliers and partners) might lead to an asymmetry of power between orchestrators. The orchestrator of strategic tasks is only relevant in the context of the ecosystem as long as it provides an important module, such as its network or financial or political standing. It is tempting for an orchestrator firm to delegate the operational tasks of orchestration to another partner, since it reduces the firm’s effort and opens new fields. However, this might lead to a situation in which the initial orchestrator becomes irrelevant. This is a particularly crucial problem in ecosystems, since the actors in this type of structure are not coordinated in a fully hierarchically way (Jacobides et al., 2018). Therefore, an orchestrator

must make sure it provides a crucial module to be firmly anchored within the ecosystem – otherwise it might be forced to leave it.

Furthermore, I observed that the three patterns – single-, double-, and multi-orchestrator ecosystems – did not change, but were strictly path-dependent in the cases. Thus, a firm must be aware that the chosen orchestrator setting is not easy to change: Once an orchestrator is crucial for the implementation of the value proposition or the coordination of partners, it is firmly anchored in the ecosystem. Although the cases revealed this strict path-dependency, ecosystems are generally dynamic rather than static. Thus, in theory, it might be possible that certain disruptive events could lead to a change in orchestration pattern, such as the strategic withdrawal or bankruptcy of a co-orchestrator. Thus, the firms would need a strong reason for this change of setting in an established ecosystem structure. This raises the interesting question of the rare circumstances under which these potential transitions between the three patterns single-, double-, or multi-orchestrator ecosystems could occur, and how firms could manage them. An exploration of highly dynamic environments could help to discover some of these transitions. This would provide orchestrators with a better understanding of how to take account of or even anticipate these transitions and how to leave the path-dependency of their orchestration pattern.

Second, I address the hitherto vague understanding of whether and under which circumstances several players might act as an orchestrator (Adner, 2017; Altman & Tushman, 2017; Iansiti & Levien, 2004b; Jacobides et al., 2018; Moore, 1996). According to the cases, the market and technological knowledge of the prospective orchestrator are the key contingencies that determine if co-orchestrators are involved in the ecosystem.

At the individual level, each firm must consider an important trade-off, which I observed in multi-orchestrator ecosystems. The degree of innovation in an ecosystem is higher in a setting with diverse orchestrators, since the various firms contribute knowledge in diverse fields. For this reason, I only observed

multi-orchestrator structures in ecosystems with highly innovative value propositions that required know-how in different fields. On the other hand, coordination between these co-orchestrators was far more challenging and protracted than coordination in ecosystems with only one orchestrator that solely coordinated the suppliers and the complementors. These observations suggest a trade-off between innovation and coordination effort between the partners.

Noteworthy, this study is not without limitations. Beyond those that come with any case study, I would like to mention three in particular.

First, the study did not reveal which orchestrator setting is most efficient. Since ecosystems are coordination structures that fall between being hierarchy- and market-based (Jacobides et al., 2018), the inter-dependency between the co-orchestrators requires considerable coordination effort. Thus, it remains an open question if it is more efficient to be the only firm to orchestrate the partners (as the cases suggest) or if involving additional co-orchestrators in these tasks is more efficient. Future research could address this question and examine which pattern of orchestration truly is most efficient.

Second, based on the cases, I have only superficially truncated the important trade-off between the degree of innovation and the coordination effort. It is possible that the higher coordination effort also prevents innovation since the co-orchestrators must find a common denominator and waste a lot of energy on coordination and political sensitivities. Future studies should examine whether the degree of innovation is truly higher in multi-orchestrator ecosystems.

Third, the study did cover slow-paced environments that do not change the customer value proposition. Since ecosystems are dynamic structures and follow a life cycle (Moore, 1993), this would have important implications for firms. Orchestrators must be more agile in fast-paced environments than in slow-paced ones. Thus, it remains unclear whether the allocation of

orchestrator tasks must be different in these fast-paced environments than in the rather slow-paced environments. In addition, these environments might be less path-dependent in their orchestrator-pattern and might reveal a more dynamic allocation of orchestrator tasks between the partners.

5.3 Contribution to Ecosystem Literature on Complementors

The findings about complementors contribute to research on the ecosystem concept and shed light on the perspective of the individual complementor as my unit of analysis. Although research has begun to consider the importance of complementors in ecosystems (Altman & Tushman, 2017; Hein et al., 2019; Jacobides et al., 2018; Kapoor & Agarwal, 2017), several authors have called for a better understanding of the roles and trade-offs of these firms (Adner, 2017; Altman & Tushman, 2017; Jacobides et al., 2018; Kapoor & Agarwal, 2017). Drawing on an embedded case study of several highly innovative ecosystems in the agricultural industry, this study aimed to shed light on the role and perspectives of complementors. I investigated the specific goals and contribution-reward trade-off between one complementor and the other actors, and the roles complementors and orchestrators can play in managing this trade-off.

First, I show that the overarching organizational goal of a complementor firm in an ecosystem determines its contribution and its role. The cases showed three basic and distinct types on a continuum, each of them leading to different problems and governance necessities. As such, it responds to the recent call by Adner (2017) for an in-depth exploration of the roles and perspectives of complementors. By demonstrating that each complementor type leads to distinct trade-offs and governance reactions from the other partners, this study also deepens our understanding of the interdependence between the different actors. In this way, I reflect the statement of Kapoor (2014) that “the literature has yet to offer an account of the collaborative interactions that exist between firms and their complementors and the challenges that accompany such interactions”.

As a second major contribution, the study moves beyond a purely static view of the role complementors can play in an ecosystem and builds on the understanding of dynamics as a central characteristic of ecosystems (Aarikka-Stenroos & Ritala, 2017; Moore, 1993; Thomas & Autio, 2014). By showing the dynamics and possible changes of complementors over time, I address the calls by Rong et al. (2013) and Thomas and Autio (2020) to pay more attention to the dynamics and interactions in the ecosystem, rather than focusing on its structure within a certain period. Whereas many studies have investigated the effects of complementor heterogeneity on the success of an ecosystem (e.g. Eisenmann et al., 2011; Jacobides et al., 2018; Wareham et al., 2014), I am, to my knowledge, the first to point to the potentially changing roles of complementors over time. Reflecting on these dynamics helps to better understand the complex interactions between the actors in an ecosystem. I hope future research will investigate the implications of these changes for the ecosystem performance in more detail.

My third major contribution is that I add to the understanding of interdependency between actors in an ecosystem. Previous literature agreed on multilateral alignment as a crucial aspect of an ecosystem (Adner, 2017; Jacobides et al., 2018) that leads to a key difference between the roles of partners in an ecosystem and complementors in platform economies. I show that a changing contribution from one complementor does have implications for all ecosystem members. However, the consequences for the orchestrator and the highly committed complementors are more severe than the consequences for lowly committed complementors. By exploring the resulting dynamics of one actor's changing contribution on the other actors, I illuminate this key conceptual characteristic.

This finding further adds to the understanding of governance of complementors, as my fourth major contribution. Previous literature agreed that it is of utter importance to secure the engagement of complementors (Boudreau, 2012; Eaton et al., 2015). However, existing papers have mostly focused on governance mechanisms from the perspective of the orchestrator

and have addressed the success factors of complementors from a holistic ecosystem perspective (T. L. Huber et al., 2017; Song et al., 2018). One of these success factors is complementor heterogeneity (Eisenmann et al., 2011; Jacobides et al., 2018; Wareham et al., 2014), but, to my knowledge, no previous study explicitly differentiated governance of heterogeneous complementors. I refine these governance mechanisms and show that orchestrators need to govern different types of complementors in different ways and continuously consider their (potentially changing) goals.

Noteworthy, also this study about complementors is not without limitations. First, this study assumes that the individual organizations that make up an ecosystem have a uniform goal. However, the involved decision-makers in an organization might follow different agendas regarding the ecosystem (Ocasio, 1997), which could be contradictory and could increase the fragility of complementor's involvement. Further research should study the effect of the involved firms' organizational structures, in which the decision-makers are embedded, on its ecosystem involvement. Second, the case sample only included dynamics between complementor types A and B. If a complementor type C changed its initially high contribution, this would, in practice, probably lead to a collapse of the ecosystem. In order to find these changes of type C complementors, it might be necessary to target failed ecosystem cases, which was not my focus. Third, the orchestrator in the three cases was a small entity with only a few people in charge of quick decision-making processes. Future studies could refine these findings and investigate how different orchestrators (such as small and medium enterprises or big corporates) can deal with the different types of complementors.

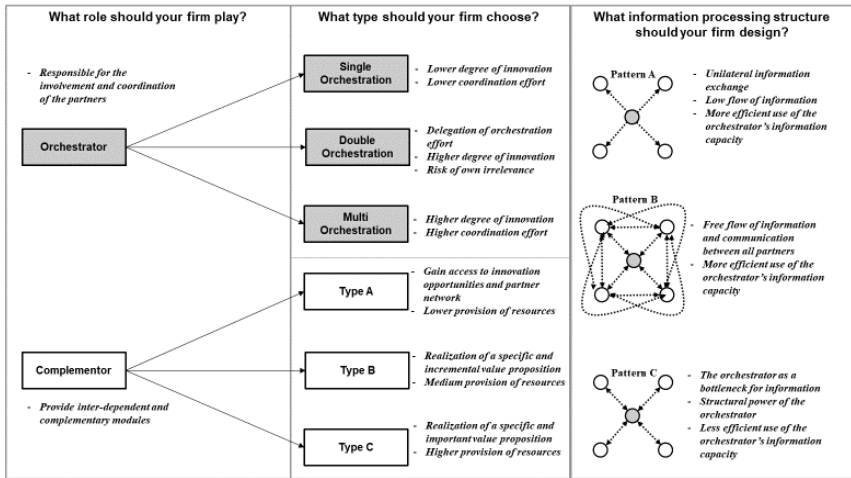
I also understand the usual methodological limitations of a multi-case study. Future studies could consider other ecosystems in highly innovative industries and could even study ecosystems in fast-moving industries. These considerations show the potential and pathways for further research on complementors in ecosystems.

6 Key Managerial Implications

Besides my contributions to literature, the findings provide several key implications for managerial practice. *Non scientiae, sed vitae discimus.*

To give managers a comprehensive overview, I consolidated the major implications of my thesis in Figure 9. It is divided into three main steps. First, a company must ask the question whether it wants to take on the role of orchestrator or complementor in an ecosystem. This decision results in three options in the second step. Potential orchestrators must decide on an orchestrator pattern consisting of single-, double- and multi-orchestrator. Complementors, in contrast, choose their own role and thus their contribution to the ecosystem. In the third and final step, the orchestrator must choose one of three organizational structures for the exchange of information. It is worth mentioning that this diagram should not be read as a strict process. In reality, the individual questions can be answered in different sequences or even simultaneously, and the ecosystems themselves are subject to constant dynamics. Therefore, this consolidated framework is primarily intended to show managers the relevant questions and options when designing an inter-firm collaboration structure in an ecosystem. It might help practitioners who are involved or thinking of getting involved in an ecosystem.

Figure 9: Consolidated Managerial Framework of this Thesis



Thus, also from a managerial perspective, the findings of this thesis provide relevant implications. For instance, the resulting framework of the first study in Figure 6 provides a systematic approach to shape the information processing among ecosystem partners. Managers of orchestrating firms might reflect on the importance of their own inherent power and design an information processing structure accordingly. Similarly, managers of complementor firms might use the findings in order to understand and perceive their own roles in terms of commitment and knowledge exchange.

Beyond the implications that arise directly from my frameworks, the findings provide several additional important learnings for managers of organizations interested in the topic of ecosystems. For instance, the display of the three patterns of single-orchestration, double-orchestration, and multi-orchestration provide three important insights for practitioners.

First, the potential of asymmetric power evolving between orchestrators over time, and the threat of irrelevance means that these firms must make sure to always be firmly anchored in the ecosystem. Managers of orchestrator firms

should therefore ensure that they provide an indispensable contribution, such as know-how, financial funding, or an exclusive network in situations when they are not firmly anchored within the ecosystem due to the chosen orchestration setup. Second, the path-dependency of the orchestration forces managers of orchestrators to consider all implications of the chosen pattern from the beginning. Therefore, before initiating an ecosystem, they need a comprehensive strategic planning and must carefully design the most suitable orchestration pattern. Third, the trade-off between innovation and coordination effort between the partners poses an additional challenge for each manager. A manager who is interested in innovation opportunities might opt for a multi-orchestrator approach for their firm. This approach likely requires a higher coordination effort and more resources, but also a higher degree of innovation. In contrast, another manager who is primarily interested in the quick implementation of a specific solution without a high degree of innovation might prefer a single- or double-orchestrator approach.

Further, the typology of complementors in Table XV shows that the organizational goal of a complementor regarding the ecosystem is the decisive criterion that determines the contribution of the complementor. First, it allows a firm to assess whether it is suitable to achieve its individual goals based on its intended or actual contribution. Second, it may help a firm understand its own roles as well as its partners' roles. Third, the firm's goals and actions have implications for an orchestrator, which the orchestrator needs to consider and keep track of. Beyond these concrete guidelines, especially my findings about complementors may provide several interesting implications for firms as well as other types of organizations interested in the topic of ecosystems. These are presented in the following both for complementors and orchestrators.

For complementors in ecosystems

On the level of the individual complementor, I argue that participation as a complementor in an ecosystem provides additional strategic opportunities for managers. First, firms can participate in an innovation opportunity without providing significant operational resources of their own. This was the case with

the complementor types A and B, whose contributions were low. This is particularly promising for decision-makers with limited resources since they can more easily initiate and pursue opportunities. Second, the potential change in contribution is a powerful steering wheel that allows firms a certain amount of flexibility and reduces their risk of commitment. I observed that the threat of a lower or terminated contribution exerts pressure on the other partners to take greater account of the complementor's incentive to be part of the ecosystem. Naturally, this is only an option for a complementor that is not heavily dependent on the specific value proposition of the ecosystem (such as type A and B complementors). Third, participation in an ecosystem with diverse actors, such as start-ups and corporates, as well as their rich networks might open innovation opportunities that go far beyond the specific value proposition of the ecosystem. This access to potential innovation partners was the actual incentive for some complementors to contribute to the specific ecosystem.

On the other hand, however, the actions and dynamics of one complementor similarly have consequences for the other complementors. In particular for complementors that depend heavily on the specific ecosystem, such as start-ups or smaller firms, the actions and potential withdrawals of other actors pose an existential risk. Naturally, from the perspective of type C complementors a fragile actor, such as a complementor of type A, is not ideal. Thus, these complementors must be willing to contribute considerably to the ecosystem in order to ensure its success. In addition to this contribution, some complementors might want to put considerable effort into their interaction with the other partners. The basis for these actions is a comprehensive big picture of the ecosystem. Thus, complementors need to understand the nature of the other actors and need to act from an ecosystem perspective rather than an individual firm perspective.

For orchestrators in ecosystems

These strategic opportunities and actions for one complementor do have implications for the other actors, such as the firms acting as orchestrators and

complementors. The interdependencies and dynamics between the actors in an ecosystem are crucial to understand and manage for the ecosystem to be successful. Therefore, the decision-makers from the orchestrators in particular need to account for the other complementors in three ways.

First, they must be aware of the goals of each individual complementor. The findings have shown that depending on its goal, each complementor type requires a different communication priority and strategy. For instance, a corporation with a low-level contribution that is primarily interested in innovation opportunities and less interested in the specific reward it could derive from the ecosystem does not require a tight exchange on the operational level. However, in this instance, there should be a regular exchange with the key decision-makers at the complementor firm, offering advantages that might go beyond the incentive of being part of the ecosystem. In contrast, a complementor that attaches great importance to the specific ecosystem primarily requires operational exchange about the specific project.

Second, the findings regarding the dynamics have shown that the goal of a complementor might change over time. Therefore, it is of utmost importance for the orchestrator to continuously track the goals of each complementor. For instance, if an internal strategic change within a complementor firm leads it to decide to reduce its contribution, the entire ecosystem might be threatened. Thus, an orchestrator needs to have continuous and sensitive communication, especially with the potentially fragile complementors.

Third, this implies that an orchestrator would prefer complementors of type C that are highly involved in the ecosystem. These are more stable and easier to predict due to their dependency on the ecosystem. Also, communication can focus on project-related issues because the orchestrator is not required to convince the complementor of the benefits of staying in the ecosystem. Thus, a complementor type C may be a firm anchor for the orchestrator. In contrast, type B and especially type A complementors pose a constant threat to the orchestrator and ecosystem stability. I have seen in the cases that the

withdrawal of these types of complementors resulted in an inferior or even defunct value proposition. Naturally, it is hardly possible to only involve type C complementors in an ecosystem. Still it might be worthwhile for an orchestrator to think about strategies that ensure complementors' contributions. Given that previous literature agreed on the importance of securing complementor engagement (Boudreau, 2012; Eaton et al., 2015), future studies might shed light on this question.

7 Conclusion and Future Research Opportunities

In summary, this thesis addresses the overarching research question of how firms can successfully collaborate in ecosystems. To comprehensively answer this question, I covered three main areas of inter-firm collaboration in ecosystems: (1) organizational structures and information processing amongst ecosystem actors, (2) the roles of orchestrators, and (3) the roles of complementors. Inspired by these three major research gaps in ecosystem literature, I conducted three multi-case studies. This chapter summarizes the key theoretical contributions along the three sub-questions (for more detailed information, please see chapter 5):

Q1: How can firms shape organizational structures amongst ecosystem partners in a way that information is processed accordingly?

The first study develops a framework that reveals three distinct types of information processing structures. In doing so, it intends to yield at least three key contributions. First and foremost, it extends the traditional views on information processing and organizational design towards inter-firm structures. Second, it elucidates how firms can shape structures amongst actors in order to appropriately process information within ecosystems. This leads to a better understanding of how ecosystems are structured and governed and sheds light on how orchestrators manage their ecosystem partners and secure their positions within an ecosystem. And, third, I show how orchestrators manage the flow of knowledge and information within ecosystems.

Q2: How can firms allocate orchestrator tasks amongst ecosystem actors?

The second study develops a framework that shows how firms allocate the key tasks of an orchestrator amongst ecosystem actors. This way, the findings contribute to the ecosystem concept in two major ways. First and foremost, I show whether, and under which circumstances, orchestrators might include other ecosystem participants in the key tasks of orchestration. Second, the

study demonstrates how orchestrators allocate these tasks to specific participants in the ecosystem. This further improves the understanding of governance of ecosystems and the steering of ecosystem partners.

Q3: How can a complementor approach the contribution-reward trade-off between itself and the other actors in an ecosystem?

The third study sheds light on the under-researched topic of complementors. It intends to contribute to the ecosystem concept in several ways. First, the cases show three basic types of complementors, with the overarching organizational goal determining their contribution and role. Second, I move beyond a purely static view of the roles complementors can play in an ecosystem and show the dynamics and changing roles of complementors over time. Third, the findings provide important implications by showing the consequences of each of the three types of complementor, both on the complementor itself as well as on the other actors in the ecosystem. These consequences are particularly relevant for firm leaders applying an ecosystem strategy to their businesses. Table XIX summarizes the key contributions of this thesis and is thereby optically based on the illustration of the research gaps in Table II.

Table XIX: Key Contributions to Ecosystem Literature

This thesis contributes to ecosystem literature by shedding light on...

- 1) ... **organizational structures** amongst ecosystem actors.
... **information processing** in ecosystems.
... **governance** of ecosystems.

 - 2) ... the roles of **orchestrators**.
... the **management of actors** in the ecosystem.
... whether and when **several players might perform the tasks of an orchestrator**.

 - 3) ... the roles and perspectives of **complementor** firms.
... **dynamics** as a central element of an ecosystem.
... **interdependencies** amongst ecosystem actors.
-

My research methodology was strongly inductive and phenomenon-based. In the course of my research, new areas emerged that might be of particular relevance for future research on ecosystems. I reflected on these areas in chapters 5.1, 5.2 and 5.3, but at this point I want to explicitly list the most important calls for future research.

Regarding the three information processing structures, the data shows a stability of the patterns over time. This stability is especially inevitable for certain patterns. For example, if an orchestrator chooses Pattern B and allows free communication between all parties, a structural separation of the partners as in Pattern C is no longer possible. Managers must therefore pay attention to which pattern they choose, as it is non-trivial to change. This path-dependency also raises relevant questions for research, as these structures have a significant impact on the long-term development of the ecosystem. Ecosystems are dynamic rather than static, and we need a better understanding of this dynamic development over the long term. Also, the data clearly showed two more efficient information processing structures (pattern A and B) and one less efficient structure (pattern C). To further measure the use of information

capacity and explore the nuances of different information processing structures open a promising path for future studies.

Further, my findings on orchestrators and the differentiation of the four orchestrator tasks in single-, double-, or multi-orchestrator ecosystems open up the possibility of several further research questions to better understand the phenomenon. Of particular interest are increasing questions regarding the coexistence of more than one orchestrator in double- or multi-orchestrator ecosystems. How do these orchestrators cooperate? And how do they manage their potentially conflicting agendas? Answering these questions would shed light on the modes of interaction between ecosystem partners as well as on the management of the trade-off between innovation and coordination effort between the partners. Firms could use this understanding to design successful ecosystem cooperation mechanisms. Also of interest, is the question of how orchestrators and their relationships with each other evolve over time. A deeper exploration of this question could provide a better understanding of the inter-orchestrator dynamics in an ecosystem and help firms anticipate or even steer these dynamics. Further, I have only superficially truncated the important trade-off between the degree of innovation and the coordination effort. It is possible that the higher coordination effort also prevents innovation since the co-orchestrators must find a common denominator and waste a lot of energy on coordination and political sensitivities. Future studies might examine whether the degree of innovation is truly higher in multi-orchestrator ecosystems.

By showing the dynamics and possible changes of complementors over time, I address recent calls to pay more attention to the dynamics and interactions in the ecosystem, rather than focusing on its structure within a certain period. I am, to my knowledge, the first to point to the potentially changing roles of complementors over time. Reflecting on these dynamics helps to better understand the complex interactions between the actors in an ecosystem. I hope future research will investigate the implications of these changes for ecosystem performance in more detail. Generally, the perspective of dynamics in

ecosystems opens a variety of future research opportunities. What are the implications for the organizational structures of ecosystems if actors leave or if new partners join the ecosystem? How does the information processing in these structures change over the course of the ecosystem lifecycle? Particularly interesting would be transitions between the type of organizational structures or even orchestration types.

Further, participant heterogeneity in ecosystems remains a to date under-researched topic. This might be particularly interesting from a cultural perspective. For instance, in my study on complementors the orchestrator in the three cases was a small entity with only a few people in charge of quick decision-making processes. Future studies could refine my findings and investigate how different orchestrators (such as small and medium enterprises or big corporates) can deal with the different types of complementors.

Lastly, my focus was on successful ecosystem initiatives with a clear value proposition according to the structural stream. However, it might be worthwhile to explicitly target failed ecosystem cases to refine existing findings and explore the dynamics in these cases. For instance, my case sample in the complementor study only included dynamics between complementor types A and B. If a complementor type C lowered its initially high contribution, this would, in practice, probably lead to a collapse of the ecosystem. The literature lacks empirical evidence of these cases. Thus, case study research on failed ecosystems might reveal relevant insights, especially for managerial practice.

Thus, despite my modest contribution to the research on inter-firm collaboration in ecosystems, many exciting questions remain open, both for practice and science. This phenomenon will continue to provide curious researchers with manifold opportunities to create new and relevant knowledge about how to collaborate in ecosystems in the coming years. I personally want to encourage these rewarding efforts. In that sense:

Nulla systema oecologicum tam difficile est, quin quaerendo investigari possit.

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Appendix

Appendix 1: Interview Questionnaire Study 1

Basics about the company/ ecosystem

- What is the value proposition of the ecosystem towards the end customer?
- Please sketch the selected ecosystem by drawing and explaining the partners, their roles, the benefits, contributions, and relationships needed for this value proposition to come true?
- How is the value creation generated and distributed within the ecosystem and what are the activities of the respective partners?
- How are the partners linked with each other, and how rigid or flexible are the respective positions?
- What are the features, strength, weaknesses and contributions of the partners involved?
- How is the ecosystem governed?

Organizational structure

- How were potential partners found and selected (selection, contact)?
- How was communication handled?
- What were the communication channels?
- Which aspects were most frequently discussed with the partners?
- Has the communication around strategic questions changed compared to the initial phase?
- How is the operational exchange between the partners managed?
- Do you communicate individually with each partner or do you meet in groups?
- Are the participants predominantly from one module or cross-module?
- Which communication channels are there? Do they differ from the communication channels for strategic questions?
- Do you know whether partners communicate directly with each other?

Appendix 2: Interview Questionnaire Study 2

Basics about the company/ ecosystem

- What is the value proposition of the ecosystem towards the end customer?
- Please sketch the selected ecosystem by drawing and explaining the partners, their roles, the benefits, contributions, and relationships needed for this value proposition to come true?
- How is the value creation generated and distributed within the ecosystem and what are the activities of the respective partners?
- How are the partners linked with each other, and how rigid or flexible are the respective positions?
- What are the features, strength, weaknesses and contributions of the partners involved?
- How is the ecosystem governed?

Orchestrators

- Who came up with the idea of the ecosystem (company, organization)?
- How were potential partners found and selected (selection, contact)?
- How did the initiator approach the partners?
 - In what order were all parties involved?
 - Were all parties involved in the discussion at the same time?
 - When you had the idea, did you meet with each partner individually or were there meetings where everyone was involved?
- Who was in the lead?
- How were the other partners involved?
- Which people from the other companies were involved?
- How is the operational exchange between the partners managed?

Appendix 3: Interview Questionnaire Study 3

Basics about the company/ ecosystem:

- Which products/ services do you offer? What is your core competence? How many/ which employees do you have?
- What is your market?
- For how long have you followed an ecosystem approach?
- How did the contact with the other ecosystem partners come about?
- What were your considerations?
- Please outline your ecosystem by jointly recording the partners, their roles, and relationships.
- What value proposition does your ecosystem offer to the customer?
- How is value added generated and distributed within the ecosystem; what are the activities of the respective partners?
- Are the partners strongly intertwined, or how strong are the connections to the respective partners?
- How is the ecosystem managed, if at all (e.g. contracts)?
- Which partner controls it?

Role:

- Which goals do you pursue within the ecosystem?
- What is your contribution to the Ecosystem (module)?
 - Does the Complementor have to align/adapt its product or service offering with participation in the BES or is the product/service generic?
 - If yes: Does the Orchestrator support the alignment process?
 - Were specific investments made to participate in the ecosystem?
- What influence do you exert on the management of the ecosystem?
- Perception:
 - How strong is your own position?
 - How important is the ecosystem for you?
 - What is your relationship to the Orchestrator?
 - What is the relationship to the other complementors?
 - Are you satisfied with the status quo?

Internal Organization:

- Who is responsible for the ecosystem in your company? Who is responsible for Strategic decisions/ Operational work?
- How is this function embedded in your company?
 - Organizational structure
 - Decision-making competence
 - Interaction with other functions
- What else is this function responsible for?
- How much time do you invest in the ecosystem and other tasks?
- Is there parallel participation in other ecosystems?

Appendix 4: Curriculum Vitae

Personal Details

Date of birth	August 7, 1993
Place of birth	Penzberg, DE
Nationality	German

Higher Education

Since 01/18	University of St. Gallen <i>St. Gallen, CH</i> Research Associate
08/16 – 12/17	University of St. Gallen <i>St. Gallen, CH</i> Master Student in Accounting and Finance
08/17 – 12/17	Babson College <i>Boston, USA</i> Visiting Student
08/15 – 12/15	Singapore Management University <i>Singapore</i> Visiting Student

Working Experience

01/18 – 12/20	Institute of Technology Management – HSG <i>St. Gallen, CH</i> Research Associate
02/17 – 03/17	PwC Switzerland <i>St. Gallen & Zürich, CH</i> Contractor Assurance
04/16 – 09/16	UBS Switzerland <i>St. Gallen, CH</i> Intern Wealth Management
01/16 – 04/16	PwC Switzerland <i>St. Gallen, CH</i> Intern Assurance